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ABSTRACT

The National Council of Teachers of Mathematics' (NCTM) "Curriculum and Evaluation Standards" recommends that mathematical connections be made between mathematics and other disciplines. This book presents 35 activities for middle school students that integrate the teaching of mathematical concepts with environmental concepts. An introduction discusses the need for mathematical connections and provides the rationale for utilizing environmental studies as a context from which to learn mathematics. Each activity provides a reference for its source, the NCTM standards for middle school mathematics addressed by the activity, student objectives, background information, materials needed, procedures, methods for closure, and evaluation suggestions. The activities are grouped according to the following environmental concepts: (1) energy and natural resources; (2) plants and animals; (3) population description and growth; (4) solid waste disposal; (5) transportation; (6) water resources; and (7) weather and air. An index classifies the activities according to the NCTM Standards for grades 5-8. The eight curriculum standards addressed are: computation and estimation; patterns and function; algebra; statistics; probability; geometry; measurement; and number and number relationships. General standards addressed by the activities are problem solving, mathematical connections, reasoning, and mathematical communication. A summary discusses how the activities were chosen and encourages teachers to let students expand the context of the activities themselves by making the activities more relevant to local issues. (MDH)

ED359052

Activities to Teach Mathematics in the Context of Environmental Studies

Barbara Thomson
Martin Hartog

March 1993

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Activities to Teach Mathematics in the Context of Environmental Studies

Activities to Teach Mathematics in the Context of Environmental Studies

Barbara S. Thomson
Martin D. Hartog

The Ohio State University

March 1993

Produced by the

ERIC

Clearinghouse for Science, Mathematics,
and Environmental Education
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Foreward

This activity guide was carefully crafted to be both responsive to current needs in mathematics education and anticipatory of emerging trends. The guide most explicitly responds to the standards recently published by the National Council of Teachers in Mathematics (NCTM). The activities presented here were specifically designed and organized to promote attention to instructional strategies associated with the NCTM standards. In harmony with current ideas and priorities, the guide also promotes active investigation and interaction among students, integration of mathematics and other school subjects, and problem solving.

This guide is also well aligned with initiatives that promote issue-oriented instruction, global awareness, and real-world applications. Each activity is this guide invites students to apply their knowledge and skills to problems and investigations of global significance. Given the complexity and magnitude of the environmental challenges we face, there could be no better context for honing one's mathematical skills and habits of mind.

On behalf of the Clearinghouse, I thank Barbara Thomson and Martin Hartog for this ground-breaking contribution. Our hope is that this will be the first in a series of activity guides that bring substance and innovation to the quest for world-class standards and performance in mathematics and science education. The Clearinghouse supports the development of activity guides in order to translate research findings and policy statements into practical ideas for instructional practice. Readers are encouraged to offer comments on this activity guide and other documents we have produced; we welcome your criticisms, suggestions, and ideas.

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Ackowledgements

The authors acknowledge the rich source of activities from which these activities have been drawn. Original sources of ideas are cited in the references provided for each activity. Readers are encouraged to send in their own activities or modifications of these activities in order to enrich later editions of this publication.

INTRODUCTION

What are the *Standards* and how can environmental studies be used to implement them?

In 1989, the National Council of Teachers of Mathematics (NCTM) published the *Curriculum and Evaluation Standards for School Mathematics* (*Standards*). This document provided a response to the call for reform made by diverse sectors of the mathematics and science education communities, as well as the education community in general. *A Nation at Risk* (National Commission on Excellence in Education, 1983) and *Educating Americans for the 21st Century* (National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983) exemplify that call for reform to which the *Standards* is a response.

As so often is the case, the actual contents of the *Standards* are not completely original. A focus on problem solving and critical thinking, for instance, was already proposed in the NCTM's *An Agenda for Action* (1981). The *Standards* did, however, provide a set of comprehensive guidelines for a new vision of the mathematics classroom, where the process by which students construct and use their own mathematical knowledge receives a higher priority than the object of that knowledge. This process would involve an increased use of manipulatives and technology in a cooperative setting to allow students to construct their mathematical knowledge.

This reform implies that the mathematics teacher will become less of a disseminator of information and more of a task chooser, who orchestrates classroom activities in a way that allows students to explore mathematical concepts, form conjectures about the relationships involved in those concepts, test out those conjectures while interacting with the teacher and peers, and look for how those relationships can be justified.

What are the "connections" called for in the *Standards*?

As a factor in the choice of appropriate activities, the *Standards* call for establishing connections among different branches of mathematics, and also between mathematics and other disciplines. Specifically, for the middle school grades 5-8:

> The mathematics curriculum should include the investigation of mathematical connections so that students can apply mathematical thinking and modeling to solve problems that arise in other disciplines, such as art, music, psychology, **science**, and business. (p. 84)

The *Standards* call for increased attention to "connecting mathematics to other subjects and to the world outside the classroom" (NCTM, 1989, p. 70). An excellent source for such connections exists in the realm of environmental issues. The middle-school student is beginning to reach the stage of development where interest in the outside world becomes heightened. As

blossoming young adults, students are beginning to see that their existence has significance beyond the safe harbor of their families and communities. A "global awareness" is growing, and environmental issues supply a setting of interest that is rich with mathematical concepts and that offers the vehicle by which the desired connections can be made. Figure 1 illustrates the growth of a middle-school student as concentric circles. The innermost circle represents the child's world at birth, with the ever-extending circle reaching out to the world as the child grows. The middle-school child has reached the stage where he or she begins to be affected by environmental issues.

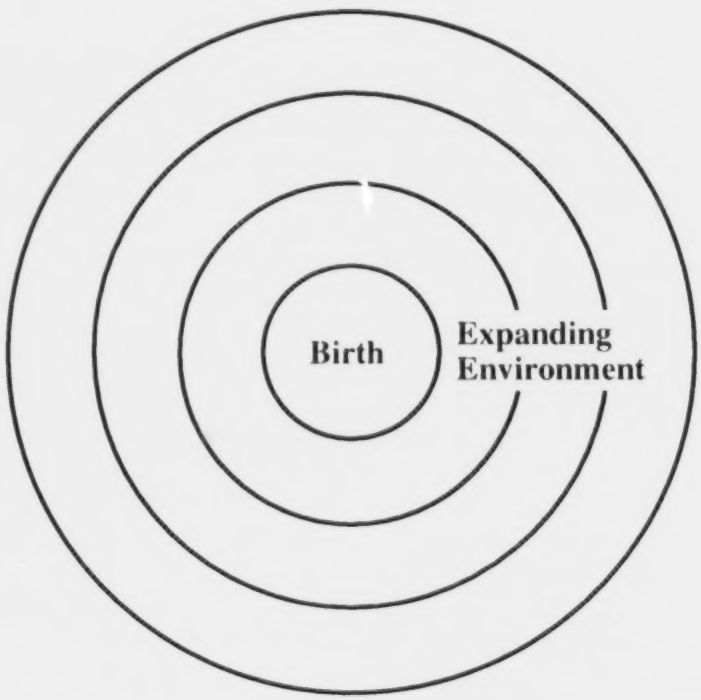


Figure 1. The expanding environment of the middle-school student.

How can Environmental Studies be used to form connections?

Using environmental studies as a context, various topics in the Grades 5-8 curriculum can be approached. This booklet of activities is organized so that overall curriculum goals of problem solving, reasoning, and communication can be interwoven with specific mathematics topics through the context of Environmental Studies. The specific content includes the topics identified in the *Standards*:

1. Number and Number Relationships.
2. Computation and Functions.
3. Algebra.
4. Patterns and Functions.
5. Statistics.
6. Probability.
7. Geometry.
8. Measurement.

This booklet chooses topics in Environmental Studies and presents suitable problems related to the topic that can be integrated into one of the content areas above. The problem-solving situations should lead to the study of the mathematical concepts inherent in the problems. This investigation can be conducted in a full-class setting, but it is the hope of the authors that teachers will encourage small-group learning to investigate the problems. The small-group setting fosters the need for students to communicate their ideas to one another and allows students to see that mathematics is not a teacher-centered body of knowledge, but a process that helps us describe the world around them.

The authors hope that this integrated approach to mathematics and science will help each student see the interrelatedness of the subjects versus an isolated view of each subject, which is all too often the result of the students' current classroom experiences.

ENERGY AND NATURAL RESOURCES

Energy Conservation

LEVEL: Grades 5-7

SUBJECT: Mathematics and Environmental Education

REFERENCES: Scharmann, L. C. (1989). Energy Conservation: A project for grades 5-7. *Science Activities, 26*(4), 8-14.

MATHEMATICS STANDARDS:
Measurement
Numbers
Patterns and Functions

OBJECTIVES: The students will learn:

1. To read meters for electricity consumption.
2. To collect and organize data.
3. To interpret percentages and ratios in solving problems.

ACTIVITY:

BACKGROUND:

This activity is taken from the article mentioned by Scharmann and was the grand prize winner for Creative Ideas. Scharmann clearly sets the stage for the activity:

"In working with energy conservation, elementary and middle school students integrate both science and mathematics concepts and skills while developing a personal conservation ethic. This project promotes an awareness of electrical energy, including its sources, commercial production, and patterns of residential consumption. Carrying out the activity develops their data collection and interpretation skills and makes them energy conscious. It puts them in the forefront of energy conservation in their homes and community and shows them that being a scientist can be fun." (p.8)

The Materials and Procedures sections come from the article.

MATERIALS:

Large sheets of paper for four classroom wall charts
Graph paper, two to four sheets per student
Xerox copies of figures 1, 2, and 3.

PROCEDURES:

1. As an introduction, explain how to read an electric meter, using xerox copies of Figure 1. Hand out student activity sheet (Figure 2) and complete the practice activity.

2. With student input, decide on the proper rules for the contest. Be sure that students understand that size of home or family affects the consumption of electricity. Thus contest winners will have to be based on the percentage decrease in energy consumption rather that the absolute decrease or the lowest amount of energy used. This is a hard concept to get across, but arriving at it by discussion teaches important skills in experiment design.

3. Prepare, with or without student help, four large wall charts listing all the students' names. Label them "Daily Meter Readings - Initial Week," "Daily Consumption in Kilowatts," "Percentage of Electricity Saved by Each Family." Set up these tables in accordance with the samples in figure 3 and 4.

4. Ask the students to read and record the numbers on their electric meters every day at the same hour for 6 consecutive days. Agree as a class on the day all will begin. Each morning have the students record the numbers for the previous day on the wall chart labeled "Daily Meter Readings-Initial Week."

5. After the first week, spend one period calculating and graphing the recorded data. Show or determine with the students how to subtract the previous day's readings from the next day's to ascertain the number of kilowatts their family used each day. Record this information on the chart labeled "Daily Consumption in Kilowatts." Then have each student graph his or her family's energy consumption pattern during 1 week, using a line graph, or simple frequency polygon, as shown in the sample graph in Figure 5. Ignoring the actual figures, do some of the graphs follow a similar pattern? Can the students whose graph patterns are similar find similarities in the way their families live and work?

6. Using the background given in this article and any supplementary sources, explain why electrical energy conservation is important. Set aside time each day to discuss ways students can decrease the amount of electricity their family uses. Students can contact local electric companies or conservation organizations to get resource materials about saving electricity. The school library may have books or pamphlets on the subject. Keep a list of all the energy-saving suggestions. Students can be very imaginative, and the number of ideas they bring in may surprise you. Some student suggestions are listed in Table 1.

7. Once the students agree that they are practicing energy-saving conservation methods to help reduce the amount of electricity used by their families, choose a date to begin taking meter readings for 6 consecutive days. Have the students record the numbers each day, calculate the kilowatts used, and enter this information into the chart labeled "Daily Conservation After Conservation Education."

8. Using the original graph, or redesigning it if necessary, add a new line to each graph to show the family's new pattern of electricity use. If all has gone well, the graph should look something like the sample graph show in Figure 6.

9. Have each student compare his or her own family's weekly energy consumption totals and then compute the percentage decrease. To do this, divide the decrease in kilowatts used by the original number of kilowatts used, to show what percentage the decrease is of the original. Fill this all in on the chart labeled "Percentage of Electricity Saved by Each Family".

CLOSURE:

In recognition of the energy-conservation efforts of the students and their families, reproduce a Certificate of Conservation (Figure 7) for each family. Fill in the name of the school or class presenting the certificate, the family name, and the percentage of energy saved. Add official signatures. Special awards can be given to students whose families show the greatest percentage decreases in electrical energy consumption.

EVALUATION:

Have the students write in their journals about their experiences in learning about reduction in electricity use.

Reading Electric Meters Activity Worksheet

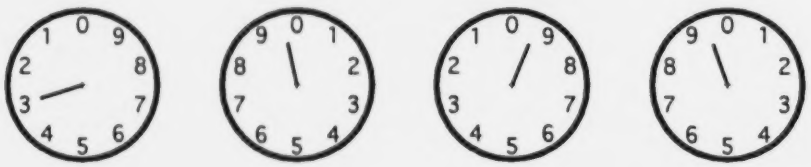
NAME _____

Directions: Read each set of dials below, and write the correct reading in the blank space.

1.

_____ _____ _____ _____

2.



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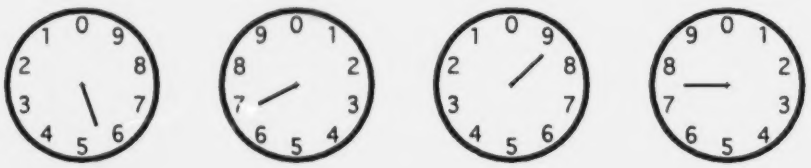

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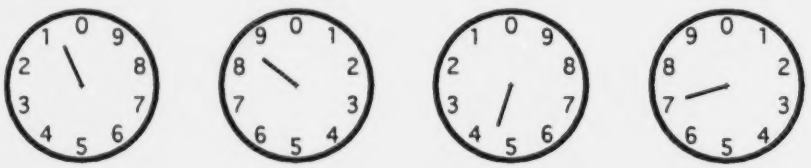

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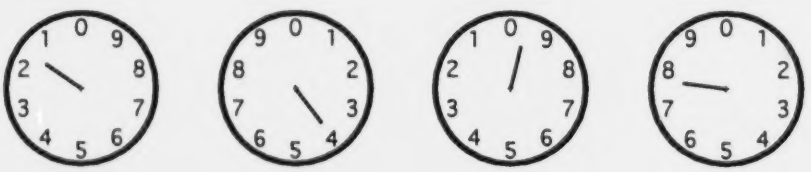


_____ _____ _____ _____

6.

_____ _____ _____ _____

Figure 1.

Reading Electric Meters

The four dials are like watch faces lined in a row (note that every other dial moves counter-clockwise). In the first illustration, the reading is 6,064 kilo-watt hours.

Write 6

Write 0

Write 6

Write 4

Notice that when the pointer has not quite reached a number, you should record the number previous—the number "0" (zero) instead of the number "1" (one) on the second dial, for example.

When the pointer on the particular dial you are recording seems to be directly on a number, look at the dial to its right; if the pointer on the right side of the dial has not yet passed "0", then write down the previous lower number on the dial you are recording. The principle (which makes sense if you think in terms of accumulating tens, hundreds, and thousands) is much easier illustrated than described. The correct reading for the meter below is: 5,459 kilo-watt hours. Your meter at home may have five dials instead of four. If it does, then you should read and record all five dials.

Write 5

Write 4

Write 5

Write 9

Figure 2.

Meter Reading Charts

Daily Meter Readings—Initial Weel
Readings in Kilowatts

Name	Sun	Mon	Tue	Wed	Thu	Fri
1. Bill	9032	9036	9042	9049	9053	9059
2. Karen	6421	6429	6438	6444	6450	6456
.	.	.	.	.	.	.
.	.	.	.	.	.	.
19. Susan	7284	7292	7299	7308	7318	7329

Daily Consumption in Kilowatts

Name	Mon	Tue	Wed	Thu	Fri	Total
1. Bill	4	6	7	4	6	27
2. Karen	8	9	6	6	6	35
.	.	.	.	.	.	.
.	.	.	.	.	.	.
19. Susan	8	7	9	10	11	45

Figure 3. Sample wall charts for first week of competition.

Consumption After Conservation Education
Readings in Kilowatts

Name	Mon	Tue	Wed	Thu	Fri	Total
1. Bill	3	6	5	4	4	23
2. Karen	6	8	4	5	4	27
.	.	.	.	.	.	.
.	.	.	.	.	.	.
19. Susan	7	5	7	7	8	45

Percentage of Electricity Saved by each Family

Name	Total kw first week	Total kw final week	Decrease in kw	Percentage saved
1. Bill	27	23	4	14.8
2. Karen	35	27	8	22.9
.	.	.	.	.
.	.	.	.	.
19. Susan	45	34	11	24.4

Figure 4. Sample wall charts for final week of competition.

Sample Graphs

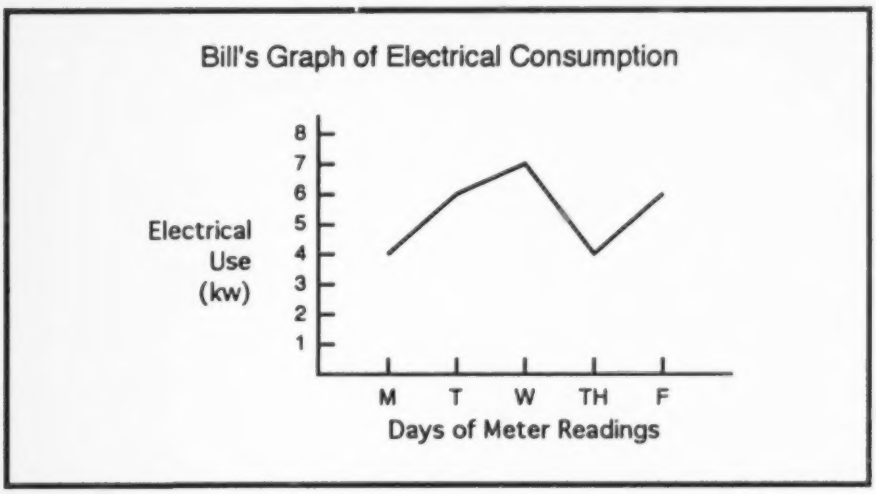


Figure 5. Sample graph showing pattern of energy consumption by one family.

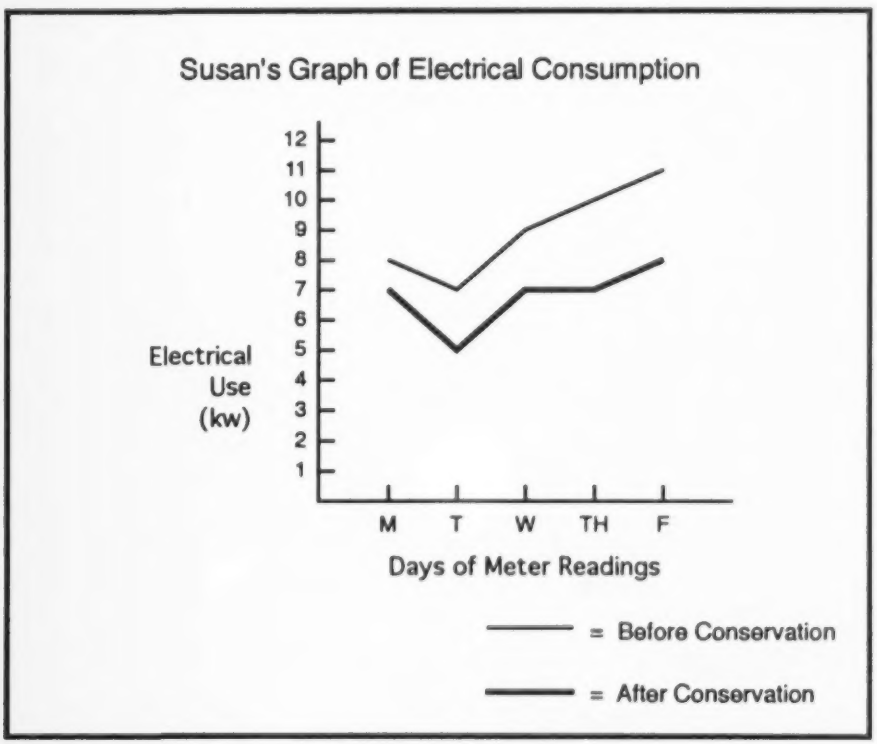


Figure 6. Sample graph amended to compare patterns of energy consumption by one family during the first and final weeks of project.

Certificate of Conservation

In recognition of the efforts of the

family to conserve electricity in their home, the students of:

present this award for energy conservation.

After learning conservation methods, the family decreased their electrical consumption by ____ %.

Congratulations

_____
Teacher

_____
Principal

Heat Absorption and Radiation

LEVEL: Grades 7-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Walton, K. D. (1988). Examining functions in mathematics and science using computer interfacing. *School Science and Mathematics, 88*(7), 604-609.

MATHEMATICS STANDARDS
Patterns and Functions

OBJECTIVES: The student will learn:

1. That different objects will absorb and radiate heat at different rates.
2. That the relationship between time exposed to the heat source and the temperature of the object is a function.
3. That this relationship can be studied via a graph.

ACTIVITY:

BACKGROUND:

The concept of function is a difficult one for students to understand. However, using laboratory activities can be helpful when students investigate concrete problems, where a relationship exists and brings about predictable variation.

Secondly, the availability of computer interfacing or thermistors that register data gathered from the environment provides immediate generation of a given relationship. The topic of heat absorption and radiation has consequences in the study of energy conservation. Solar heating of homes is an example that could be discussed. It can be studied in the classroom using heat-sensitive probes interfaced with a computer or by recording temperatures manually.

MATERIALS:

Computer or blackboard graph
2 heat-sensitive probes (thermistor)
Software to use the computer as a thermometer.
(e.g., science tool kit by Broderbund $54.00)
Black tab
Shiny tab

PROCEDURES:

After discussing the importance of different rates of heat absorption and radiation a laboratory is conducted. Two aluminum tabs of metal about 6 inches by 6 inches, one painted a flat black and the other shiny, are attached to a piece of styrofoam. A slot is cut out in the styrofoam to allow for a thermometer or thermistor to be inserted. (See Figure 1.) The thermistor is hooked up to the computer or the thermometer is checked manually by the students, so that the temperatures will be registered as a function of time. Two 100-watt bulbs are set up so that their light and heat are equally distributed to the two tabs.

As the tabs heat up, the graphs on the computer are registered on the screen or plotted by the students (see Figure 2). The differences in the rates of increase can be seen in the graph. Students are asked to interpret the differences in how the lines climb. The concept of rate can be introduced and its connect to the steepness or "slope" of the line shown. This means that the black tab is absorbing heat faster than the shiny tab.

A second experiment can also be performed. Move the light closer to the shiny tab so that both tabs reach the same temperature. Then turn the lights off and let the computer register the temperatures. Let the students again interpret the graph.

Mathematics teachers will probably need to enlist the cooperation of the science teacher to see if software like the Science Tool Kit is available and exactly how it works. If software isn't available, long experiment thermometers will be needed so temperatures can be registered by hand. Using students to check time intervals, read the thermometers, graph the points, etc. may even be an advantage.

CLOSURE:

1. Let the class register their conclusions about the two phenomena of absorbing and radiating heat.
2. Discuss how these phenomena represent functions.
3. Discuss the consequences of these phenomena in energy conservation.

EVALUATION:

Have each student write his or her own interpretation of how this activity represents a function and also how the concept of a faster rate of increase translates to the graphic representation of the phenomena.

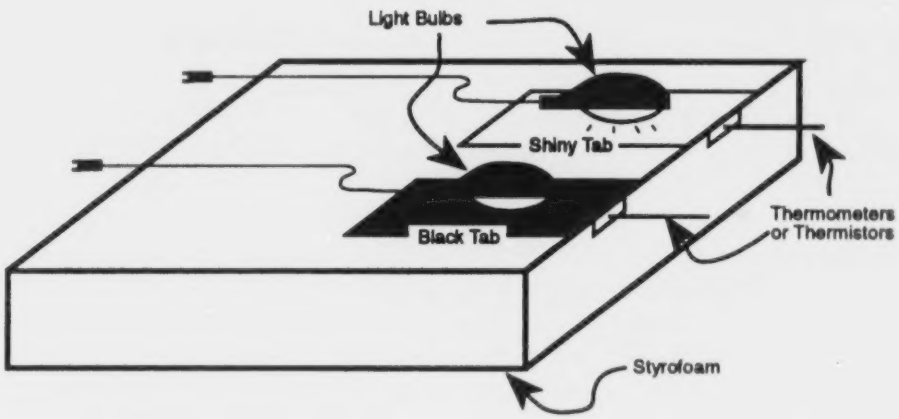


Figure 1. Heat Absorption.

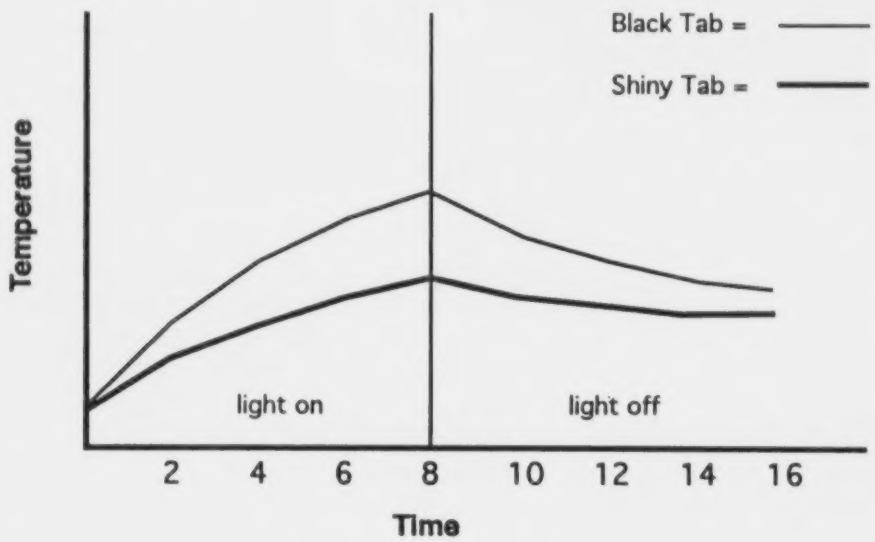


Figure 2. Graphs of Results.

Prospectors

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Wiebe, A. (Ed.). (1984). *Down to earth solutions for mathematics and science*. Book 6. Fresno, CA: Aims Education Foundation. (ERIC Document Reproduction Service No. ED 283705).

MATHEMATICS STANDARDS:

Measurement
Number and Number Relationships
Problem Solving

OBJECTIVES: The students will learn:

1. To measure appropriate quantities
2. To use ratio, proportion, and percent in meaningful ways.
3. To confront a practical problem and work cooperatively to solve it.

ACTIVITY:

BACKGROUND:

Discuss some of the ideas involved in running a mining business with the class. How much do they know about mines? Much of their information may come from watching western movies like "King Solomon's Mine" or "Indiana Jones". In some communities mines are economically important. Make a list of ideas they have. Divide students into 4 or 5 teams and have them conduct some library research using encyclopedias, *Reader's Guide for Periodicals*, and mining books. The State Department of Natural Resources may also have some materials if you are in a state that has either strip or shaft mining. Students will be able to explore and locate material in cooperation with you and the librarian. It will be interesting to see how much thought they have put into this type of endeavor. The question of determining how rich the soil is will almost certainly arise. The natural consequence of this question is how many minerals can be extracted from the ground. This activity, adapted from Wiebe (1984), gives students the opportunity to experience this problem on a simple level and to look for possible solutions.

MATERIALS:

Eye protection
Worksheets
Iron filings (available at machine shops) ("Iron Ore")
Sawdust (available at lumber yards) ("Pulpwood")
Small plastic bags
Paper cups
Sand
Scale
Magnets ("Magnetic Separator")
Glass dishes
Balance & gram weights
Plaster of paris
Hammer ("Ore Crusher")
Paper coffee filters ("Sediment Filter System")
Strainer
Small pan
Calculators

PROCEDURES:

The goal is to have students determine the compositions of a simulated core of a mountain made out of plaster of paris, iron fillings, sawdust, and sand. It's possible to let students create their own simulated cores or the teacher may want to make different cores. Weigh the amounts of sand, iron ore, and pulpwood in plastic bags. Mix in with the plaster of paris, and add only enough water to make the plaster thick. Put the mixture in a paper cup to dry. Students then have the task of deciding how rich in minerals their prospective mountains are by extracting the minerals from the core samples they have.

If you decide to let the students make the cores, make them the day before your start to extract the minerals. Divide the students into groups of 4 or 5. One student will be designated as the foreman and the others as workers. The team will create cores using paper cups as a form. Each group will keep a record of the minerals in their simulated core. Groups will then exchange cores with one another, and their task will be as follows:

DAY 1 & 2:

1. Take the simulated core sample of the mountain out of the cup.
2. Make a plan on how to extract the minerals and in what order. The most successful operations use the following method:
   a. Use the hammer to pulverize the material. (Students should cover the material with a towel and use eye protection!!)

b. Use a magnet to extract the iron.

c. Place remaining material in water. Remove floating sawdust.

d. Pour through a filter, trapping the plaster of paris and sand.

e. Place the plaster and sand into a dish and add water. The sand will sink with some plaster. Pour off the floating plaster. Pour through another filter. Add more water, stir, and pour off floating plaster. Continue until all the plaster is floated off. Let the sand and sawdust dry before measuring.

3. Extract the minerals from the samples.

4. Record your work and measure the mass of each material, and record your total mine output . (See worksheet 3.)

DAY 3: The team must now evaluate their mine and its materials. Calculators will be useful here.

1. Develop your percentages of each material you "mined" using the effectiveness study chart on Worksheet 1.

2. Continue with the cost analysis section of Worksheet 1.

   a) Determine the income according to the miners handbook (Worksheet 2).

   b) Determine your expenses from the equipment used and labor costs (Worksheet 2).

   c) The difference between expenses and income is the amount of profit.

3. The team will then determine how effective the mining was by comparing the amounts of the "mineral" extracted and the amounts in the cores exchanged by the groups or supplied by the teacher.

4. Each team will then make a recommendation as to whether or not the company should continue. (See worksheet 4.)

CLOSURE:

The proposals will be presented by each group to the class.

EVALUATION:

Each student will be asked to explain in his or her mathematics journals how the effectiveness of the extraction method used is determined.

Worksheet 1 **Evaluator** _____

Allied Mines

Evaluator's Annual Report to the Board

COST ANALYSIS

*** INCOME ***

MATERIAL	Quan(g) x Price(g)	= Sales

TOTAL GROSS INCOME _____

*** EXPENSES ***

EQUIPMENT REQUISITIONED		
ITEM	QUAN. x COST/UNIT	= TOTAL

TOTAL EQUIPMENT COST _____

TOTAL (gross) INCOME _____
EQUIPMENT COST – _____
_____
PERSONNEL COST – _____
NET INCOME _____

PERSONNEL EMPLOYEE	Hrs. Work	Wages/ Hour	TOTAL

TOTAL COST _____

EFFECTIVENESS STUDY

MATERIAL	RECOVERED AMT.	ACTUAL AMT.	PERCENTAGE

Worksheet 2 **Miner** _____

Allied Mines
MINER'S HANDBOOK

ACE MINING EQUIPMENT

PRICE LIST

Ore Crusher	$35.99
Settling Tank	17.95
Evaporating Bed	16.98
Sediment Filter System	11.95
Magnetic Separator	24.95

CENTRAL COMMODITY EXCHANGE
(select daily reading)

BEEF/head	$215.20
BORAX/g	21.15
COPPER/g	95.10
CORN/bushel	12.10
IRON ORE/g	85.70
GOLD/g	415.20
PULPWOOD/g	43.25
SALT/g	24.53
SILICA SAND/g	53.90
SILVER/g	120.25

UNITED MINE WORKERS (UMW) SALARY SCHEDULE
LOCAL #95

BASIC SALARY

FOREMAN	$11.00/hr
COMMON LABOR	8.00/hr

BENEFITS

The following benefits are to be included in the salaries of all workers:

MEDICAL	$2.50/hr
RETIREMENT	1.50/hr

Worksheet 3 **Prospector** _____

Allied Mines

PROSPECTOR'S REPORT

DATE: _____

MINING PROCEDURE

EQUIPMENT REQUISITIONED

TOTAL MINE OUTPUT

SUBSTANCE MASS (g)

MINER'S TIME CARD

Job Done	Day 1	Day 2	Day 3	TOTAL TIME
			TOTAL HOURS WORKED	

Worksheet 4 **Evaluator** _____

Allied Mines

RECOMMENDED ACTION:

- ❑ MAINTAIN OPEN MINE. CONTINUE PRESENT PROCEDURE.
- ❑ MAINTAIN OPEN MINE. REVIEW AND EVALUATE PROCEDURE.
- ❑ TEMPORARILY CLOSE MINE. REVIEW AND EVALUATE PROCEDURE.
- ❑ PERMANENTLY CLOSE MINE.
- ❑ OTHER (EXPLAIN).

EXPLANATION:

Turn Off the Lights!

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Kimmel, H. (1982). Energy Topics in the Mathematics Classroom. *School Science and Mathematics*, 82(4), 271-278.

MATHEMATICS STANDARDS:

Problem Solving
Number or Number Relationships

OBJECTIVES: The student will learn:

1. To calculate power usage.
2. To plan an energy budget.
3. To make decisions using mathematical data.

ACTIVITY:

BACKGROUND:

Natural resources are not inexhaustible, especially considering that our population is continually growing. Suppose we were told that we had to ration electricity. It would be necessary to know how we should budget that energy to provide for its greatest utility. This activity will enable students to look at how they use electricity and force them to make decisions about how it should be allotted.

MATERIALS:

Electricity rates in your area
Worksheet
Calculators

PROCEDURES:

The phrase "Turn off the lights!" is one that most students have heard before but have rarely given any consideration to. However, it's possible that there might not always be unlimited sources of electricity. Discuss in class, the day before the activity, what might cause limited availability of this resource. The students will need to identify electrical equipment in their homes and the amount of electricity it uses. The teacher will discuss how to calculate electricity consumption.

The following are examples of how electricity consumption can be calculated.

Electrical Item	Number	Average Voltage	# hrs./day	KW/ hr/month
60W bulb	5	60	5 x 6 = 30	$\frac{30 \times 60}{1000}$ x 30 = 54KWH
75W bulb	2	75	7 x 2 = 14	$\frac{14 \times 75}{1000}$ x 30 = 32KWH
Refrig.	1	320	24 hrs	$\frac{320 \times 24}{1000}$ x 30 = 230KWH

The following day, worksheet 1 will be given out to groups of 3-4 students. Each group will be a "family" and will have to make a budget for the use of their electricity depending on the appliances and electrical uses they have. The total number of kilowatt hours will be negotiated by the students. Students will then make a budget that will provide for the essential needs of the family. Calculators will allow students to quickly readjust their budgets as they make changes in how much time they decide to use each appliance.

CLOSURE:

Students will present their budgets to the rest of the class, giving justification with respect to their decisions. Discussions regarding the different priorities can be interesting.

EVALUATION:

Given a fixed number of kilowatt hours for lighting, have the students explain in their mathematics journals the relationship between the number of hours a bulb of a particular wattage can be used and the wattage of the bulb.

Worksheet 1

Each "family" will be restricted to a monthly allotment of __ KWHs. Using the information on the appliances you've found in your homes, fill in the chart below and decide how many hours of use each appliance will be allotted each day. (If certain appliances will be used on a weekly basis, make the appropriate adjustments.)

Appliance	Average Wattage	Hours/day	KWH/month

WARNING: You'll probably need to make several adjustments before you are satisfied with the time allotment you have determined for all the appliances.

PLANTS AND ANIMALS

It's a Jungle Out There!

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Thomson, Barabara S.

MATHEMATICS STANDARDS:

Patterns and Functions
Statistics
Mathematical Connections
Mathematics as Communication

OBJECTIVES: The students will learn:

1. To collect data using media productions.
2. To make mathematical connections.
3. To use mathematics as a language.
4. To acquire data and transfer the data to communicate the information in a mathematical format.
5. To communicate information using mathematics.

ACTIVITY:

BACKGROUND:

The movie industry has constantly utilized rain forests and jungles to make a variety of movies, starting with the Tarzan series. Students will select movies to view in order to study the plants, animals, habitats, and scientific accuracy of these movies. The learners will put these data into a report using mathematics to communicate the information in an effective way.

MATERIALS:

Library or Resource Center

PROCEDURES:

1. Students will identify movies made in jungle/rain forest settings. They will study and develop an operational definition of jungle and rain forest. They will view the films and make lists of the animals, plants, and habitats. Research will be done at the library to determine accuracy of the Hollywood films.

2. Data will be collected, analyzed, and summarized. Students will be asked to determine interesting ways to report these data using mathematics. Communicating with mathematics is the focus of this project.

3. Students might compare films from the 1930s with current films. A wide variety of films are available on videotape. Students should be challenged to be creative in using films for environmental data.

CLOSURE:

Students will write a movie review using their data, graphs, charts, etc. Students can interview each other and create a talk show scenario. Clips of the films could be shown during a PTO night at school.

EVALUATION:

Students will write a paper showing their data and supporting documentation for their findings.

The Environmental Observational Human

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: American Association for the Advancement of Science. (1972). *Science: A Process Approach.*

MATHEMATICS STANDARDS:

Mathematical Connections
Mathematics as Communication
Statistics

OBJECTIVES: The students will learn:

1. That humans have certain strengths in learning about the environment.
2. That some humans have observational skills that are different from others' skills.
3. That utilizing abilities of different humans will enhance communicating about the environment.
4. Techniques for identifying observational skills.

ACTIVITY:

BACKGROUND:

Learners have different learning strengths. This activity will use the environment as a tool to identify those learners with excellent observational skills. Everyone has certain strengths and weaknesses, and it is important in a cooperative learning setting to capitalize on the strengths of each person. Observational skills are useful in both science and mathematics, and the most skilled in the area of observing can be utilized during data-gathering sessions to assure high-quality information.

MATERIALS:

A land laboratory, park, nature center, or the school neighborhood can be the site
Clipboard
Worksheet

PROCEDURES:

Divide the class into cooperative learning groups with three people in each group. The Observation Data Sheet (ODS) should be on each clipboard. The cooperative learning groups will observe and record things they hear, see, touch, and smell, and also record anything that is happening in the environment.

Upon returning to class, each group will summarize its observations and make a graph that communicates observational skills. Communicating with mathematics will be the emphasis.

CLOSURE:

Share the graphs and charts with the entire group. Critique the techniques used to communicate environmental observations. Can all the data be put together? How might the data be pooled and the information be used in charts and graphs.

EVALUATION:

Each group will develop a proposal for using all the data in a mathematical way to communicate observational skills in the environment. What makes a good observer? List the ways you could improve your observational and reporting skills.

Environmental Observational Data Sheet

NAME_____GROUP NAME_____

DIRECTIONS:

Make observations all around you in the area. What do you hear, feel, see, and smell? Do not taste anything without checking with your teacher. What is happening around the area? Describe what you see. Be accurate and work with your cooperative learning group to carefully gather data.

Back in the classroom create a graph or chart to summarize your data. What makes a good observer? Are some people better observers than recorders?

Things I Saw:

Things I Heard:

Things I Felt:

Things I Smelled:

Things That Were Happening:

The 1/32nd Challenge

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: United States Department of Agriculture: Soil Conservation Service

MATHEMATICS STANDARDS:

Mathematical Connections
Mathematics as Communication
Computation and Estimation
Number and Number Relationships

OBJECTIVES: The students will learn:

1. The relationship between the total earth systems and the amount of productive land for food production.
2. To communicate about the interrelationship between the productive land mass and the productive layer of top soil.
3. The importance of making connections between population expansion and productive land utilization.

ACTIVITY:

BACKGROUND:

The entire earth system seems very large and diverse. However, one of the most critical resources on this earth is the topsoil used to produce food for an expanding population. Although the food-producing land remains the same, the world population is continuing to expand. This activity is a visual demonstration about the productive land that can be used for food production.

MATERIALS:

Large apple
Serrated paring knife or plastic knife

PROCEDURES:

1. Cut the apple into four equal parts. Three parts represent the oceans of the world. The fourth part represents the land area.
2. Cut the land section in half lengthwise. Now you have two 1/8th-sized pieces. One section represents land such as deserts, swamps, Antarctica, the Arctic, and mountain regions. The other 1/8th-sized section represents where humans can live and grow food.
3. Slice this 1/8th-sized section crosswise into four equal parts. Three of these 1/32nd-sized sections represent the areas of the world that are too rocky, too wet, too hot, or where soils are too poor for production, as well as areas developed for businesses or living. The last 1/32nd-sized section represents the land mass on which we grow food crops.
4. Carefully peel the last 1/32-sized section. This small bit of peeling represents the topsoil of our earth or the productive layer upon which everyone depends for food production.
5. Discuss what is occurring in your own community with productive farm land?

CLOSURE:

Invite a city planning commissioner to your classroom to explore the long-range plans for your community. Discuss the importance of productive land and discover what laws protect this valuable resource in your community.

EVALUATION:

Write an article for your local city, neighborhood, or school newspaper discussing this topic. Interview a politician to learn more about that individual's philosophy concerning the protection of food-producing lands. Videotape this interview for a local television show or make an audiotape for a local talk show host to use. Remember that reporters must be objective and accurate in reporting the data.

The Seedling Competition

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Zipko, S. J. (1983). How to do it: An interdisciplinary approach to forestry education. *American Biology Teacher, 45*(7), 387-392.

MATHEMATICS STANDARDS:
Number and Number Relationships
Problem Solving

OBJECTIVES: The students will learn:

1. To review ratios and percents of germination and plant growth.
2. To use these comparisons and percents to solve problems regarding forest management.

ACTIVITY:

BACKGROUND:

Projects that provide for periodic review of certain concepts can be beneficial. As an exercise to review the concepts of percentage, ratio, averages, and graphing, this activity utilizes the environmental issue of forest management in a problem-solving setting.

Zipko (1983) reports: "This indoor lab activity is designed to show that growing plants, whether trees or vegetables, compete for various environmental needs" (p. 389). Because density of seedlings influences their growth rates, students should experience thinning a population of growing plants in several different ways to observe which method promotes the fastest growth of the seedlings.

For this lab, the growth rate of several varieties of pea (Pisum sativum) can be observed to better understand which techniques the lumber industry uses to promote the fastest growth to satisfy our need for wood and paper products.

MATERIALS:

1-gallon plastic milk containers with tops cut off
Soil
Seeds for one variety of pea per group

PROCEDURES:

Students will work in groups with each group responsible for a given variety of pea. Each group will be given a milk carton and soil in which to plant seeds. The objective of the experiment is for each group of "foresters" to have the most seedlings measuring over 10 cm in height in 3 weeks. To accomplish this, the members of the group must decide if, when, and how to thin out some of the seedlings planted in order to encourage rapid growth of the others.

At the end of the first week, the group will calculate the percent of germination and the average height of their plants. These data will be registered on their worksheets and plotted on the graph of the first week's data. Each group will decide on thinning procedures at this time.

At the end of week 2, the students will again calculate the average height of the plants. Again these data will be registered on their worksheets and plotted on the graph for week two. (See Figure 1 for an example of the graph.)

At the end of week 3, the final data will be calculated, finding how many plants remain, the percent that have attained a height of more than 10 cm, and the average height at the end of week 3. The groups will then respond to the worksheet questions.

CLOSURE:

Students will discuss their results and their tactics in attaining those results. Ramification of these results will be discussed for the forestry industry evaluation.

EVALUATION:

Students will be asked to explain how the thinning process can be effective, backing up their arguments with mathematical data and reasoning.

Worksheet

GROUP MEMBERS:

WEEK 1:

Number of seeds planted:
Number of seeds germinated:
Percent of seeds germinated:
Average height of plants after 1 week:
Number of plants retained for week 2:
Explain why you decided to retain this number of plants.

WEEK 2:

Number of plants remaining:
Percent of original number of seeds planted:
Average height of plants after week 2:
Number of plants retained for week 3:
Explain why you decided to retain this number of plants.

WEEK 3:

Number of plants remaining:
Number of plants over 10 cm:
Percent of plants from original seeds over 10 cm:
Average height of plants after week 3:

QUESTIONS:

1. What was the rate of growth of the plants during week 1? week 2? week 3?

2. Was your plan successful or not? Explain.

3. What would you do differently to yield a better crop?

4. How does this experiment help understand forestry management?

Graph of Growth Progress

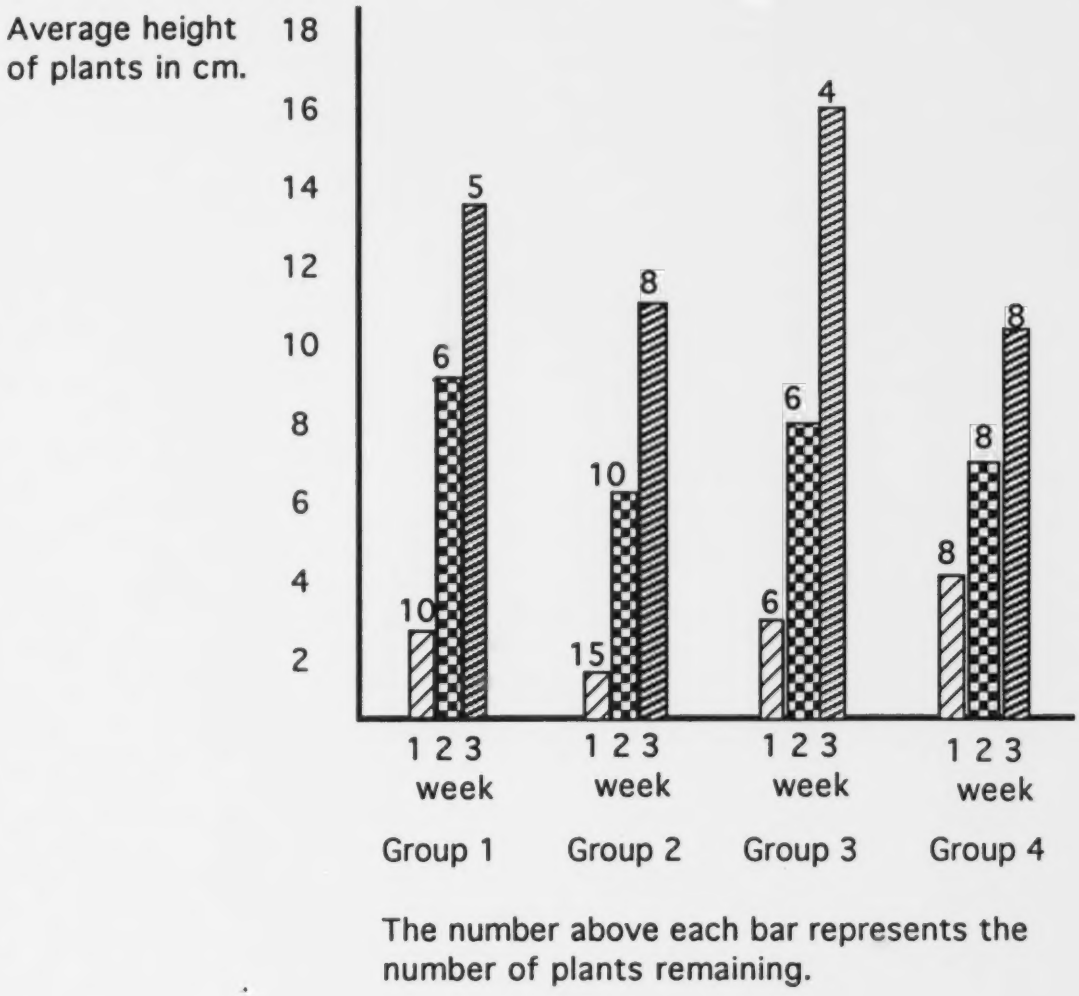


Figure 1. Graph of growth progress.

To Save or Not To Save: That Is the Question

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Utilize materials from:

1. World Wildlife Fund, 1250 Twenty Fourth St. NW, Washington, D.C. 20037.
2. Your state Department of Natural Resources.

MATHEMATICS STANDARDS:

Mathematics as Communication
Statistics

OBJECTIVES: The students will learn:

1. To develop an appreciation for the loss of plants and animals in the world.
2. To synthesize the loss of organisms into a mathematical framework.
3. To communicate mathematically in an efficient and readable style information about extinct, threatened, and endangered species.
4. To read and interpret legislation passed by Congress.

ACTIVITY:

BACKGROUND:

The Endangered Species Act has created some assistance for organisms that would probably be extinct if the United State Congress had not enacted this law. However, many different groups are challenging this law and would like to have it changed or even eliminated. What are the strengths and weaknesses of this legislation? What kind of data supports or challenges this legislation?

MATERIALS:

Paper and pencils
Resources - both human and printed

PROCEDURES:

Students can work in pairs or in small groups to investigate the different challenges to the Endangered Species Act. Using the library or possibly interviewing individuals active in this cause, the students will gather information supporting or rebutting the challenges. Sharing information will be important among all members of the class even though they are working in small groups. A reporting period several times a week will be necessary. Each group could have a briefing conference with a one-page handout of information that they feel is important for the other groups.

Each group will eventually select one aspect of this topic and contribute to a class report. The groups will develop mini-reports using charts, graphs, and other mathematical ways to report. Should species be saved? Are jobs important? Which organisms have become extinct locally? What are the various arguments for or against this issue? What will this mean for the future? Many different topics could be used. The class will need to prioritize the most important topics and make research assignments. A final class document will be prepared.

CLOSURE:

Students will present their document to their local government, the state legislators, or send the report to Congress. The local U.S. Representative from your district may be able to schedule a visit to your school. Be creative in pursuing this project.

EVALUATION:

Request that experts from a local university, college, academy of science, businesses, Department of Natural Resources, or other experts critique your class report. Review the critique. Discuss the changes and reasons for the recommended changes.

Tree Cookies

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Wiebe, A. (Ed.). (1984). *Down to earth solutions for mathematics and science.* Book 6. Fresno, CA: Aims Education Foundation. (ERIC Document Reproduction No. ED 283705).

MATHEMATICS STANDARDS:

Geometry
Measurement
Problem Solving
Patterns and Functions

OBJECTIVES: Students will learn:

1. About tree growth and its dependence on environmental factors.
2. About the relationship between the radius and the circumference of a circle.
3. Different ways to compare growth in a tree.

ACTIVITY:

BACKGROUND:

The following information as reproduced from the Aims worksheet for the activity provides ample information on which to build this lesson:

Tree growth depends on environmental factors including location, surrounding foliage, water and temperature. The yearly variance of these factors may be reflected in a tree's annual growth rings. Counting these growth rings gives a fairly accurate account of a tree's age. The wider the rings, the more growth. The narrow rings will indicate less growth due to drought or cold cycles. Growth occurs only in one small microscopic layer of the tree called the cambium. The cambium layer lies next to the sapwood. As it produces cells, the tree grows. The other parts of the tree trunk are basically dead. The pith is the center of the rings. Its position, whether in the exact center of the round or offset to one side, can indicate growth factors like the amount of shade from surrounding foliage. The heartwood is the darker area surrounding the pith that consists of closed capillary

passages. This former sapwood now functions as the fortification part of the tree. The sapwood is the next layered section. It is lighter in color than the heartwood (if the round is a fairly fresh cut). The sapwood functions as a transportation system for the fluids and nutrients to pass up the tree to the outer branches and leaves. (p. 16)

Figure 1, presenting the parts of the tree, also gives the student good visual information from which to respond to Worksheet 1.

MATERIALS:

Tree Cookies (Cross sections of a tree trunk that may be obtained from the Forest Service or a local tree trimming company and should be sanded down to bring out the rings.)
Metric tapes
String, rulers
Worksheets

PROCEDURES:

After presenting the background material, the teacher will present the tree cookies to the students. It will take two days to complete the lesson. The main question of discussion here is how can the students describe the growth of the tree from looking at the tree cookie and how can we use mathematics to describe that growth.

The first day, in a large-group discussion, the students can discuss the parts of a tree. Figure 1 and the background information provided will allow the students to learn about the life cycle of a tree. Many students will wonder if you are teaching biology or mathematics. Students can discuss and interpret the number of rings and their relative size. The challenge can then be issued as to how to quantify the life of the tree. Worksheet 1 explores the life of the particular tree from which the tree cookies came.

Worksheet 2 explores the life of the tree by comparing the distance from the pith to a given ring and the distance around that ring. The worksheet provided will show how this relation can be studied through number patterns seen by the students in a table showing the ring number, the distance from the pith to the ring, and the distance around the ring. These patterns can then be used to make decisions about future tree growth.

The teacher is encouraged to adapt the lesson to the level of the student. Exploring the different comparisons can be used to introduce the mathematical terms *radius* and *circumference* of a circle.

CLOSURE:

Students will report their findings to the full class. The discussion can be utilized to introduce the need for common language in mathematics to describe what they found.

EVALUATION:

A homework assignment in which the students respond to questions that might arise from the activity. Wiebe (1984, p. 16) provides sample questions :

1. How can we identify the heartwood from the sapwood? The inner bark from the outer bark?

2. What is the constant when you divide the circumference by the diameter? What is the relationship between the diameter and the radius?

3. What factors do you think might affect the position of the pith?

4. When does a tree have its greatest percent of growth?

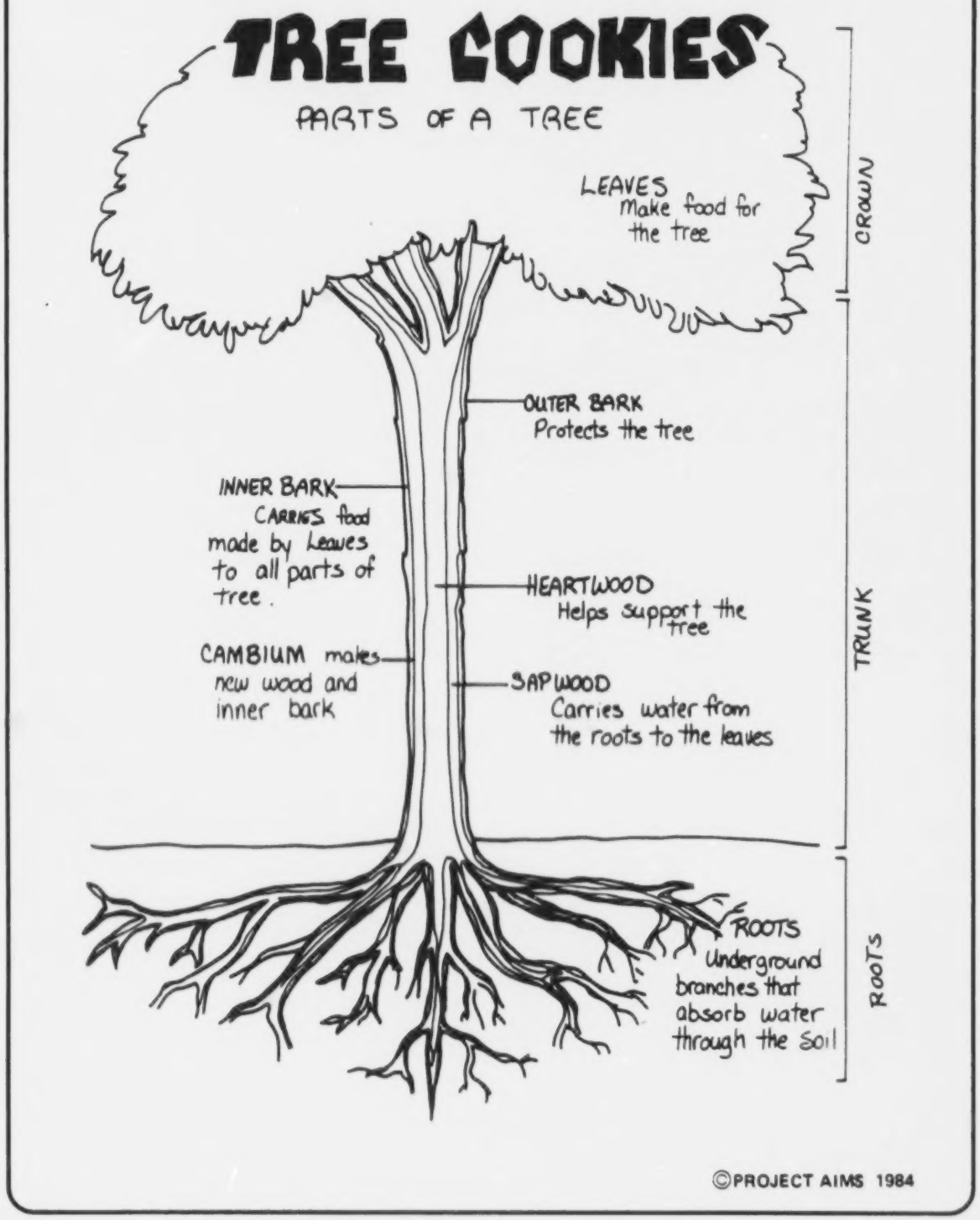
5. Are the rings of the tree all the same size? What might account for the different widths in the rings?

6. Is there a relationship among trees within a certain area?

7. Can we determine the year in which a tree germinated?

8. Are trees with the same diameter the same age? Why?

Tree Cookies

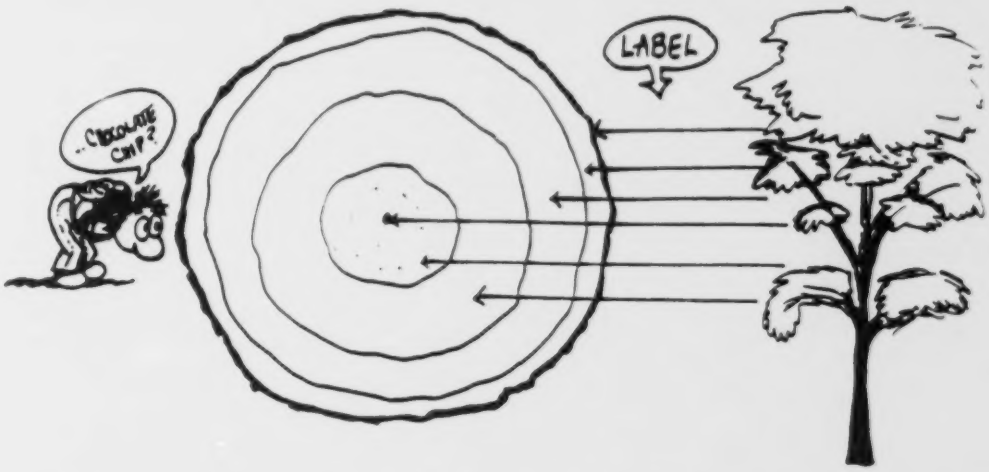


Tree Cookies Worksheet 1

Each group will need a recorder and one person to report your findings to the class.

QUESTIONS:

1. Label each of the parts of the tree on the cross section in the diagram below.



2. Now look at the tree cookie that your group has and identify the parts of the tree. Is it easy to see?

3. How old was the tree from which your tree cookie came when it was cut down?

4. In what year was your tree planted if it was cut down in 1991?

5. During what year did your tree register its greatest amount of growth? the least amount?

6. What is the distance from the pith to the inner bark? to the tenth ring?

7. What percentage of growth took place in the first decade of growth?

Tree Cookies Worksheet 2

Your job is to describe the relationship between the distance from the pith to a given ring and the size of the tree around that ring. Answering the following questions should help you organize your thoughts about this question.

1. Complete the chart below that gives the age in years of the tree, the distance from the pith to the outer bark for that year, and the distance around the ring for that year. Use your rulers and string to calculate those distances.

Age in years	Distance from Pith to Outer Bark	Distance Around the Tree
5		
10		
15		
20		

2. From the table, can you see any pattern to the numbers? If so, what is it?

3. Can you now predict the distance around the tree when it was cut down? What is it?

4. Check your answer by measuring the distance around the tree.

5. Can you predict what the distance around the tree would be if the tree continued to grow so that the distance from the pith to the inner bark was 10mm more?

Trees as a Crop

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education.

REFERENCES: Wiebe, Aurthur (Ed.) (1984). *Down to earth solutions for mathematics and science* . Book 6. Fresno, CA: Aims Education Foundation. (ERIC Document Reproduction Service No. ED 283705).

MATHEMATICS STANDARDS:

Geometry
Number and Number Relationships
Mathematical Connections
Measurement

OBJECTIVES: The students will learn:

1. How foresters manage and maintain the forest.
2. Ideas related to measuring trees and their productivity.

ACTIVITY:

BACKGROUND:

The forest, once viewed as an inexhaustible resource, is in jeopardy today. Introductory remarks for this lesson should include that the forest is needed to help reverse the current greenhouse effect by turning CO_2 into oxygen. Another reason to maintain the forest is the role trees play in soil protection from wind erosion.

Controlling the harvesting and replanting of trees, therefore, becomes an important problem for foresters. Knowing when to cut a tree down is an important decision to make. Mathematics enters into making that decision. This activity helps determine the potential yield of a stand of trees by determining the heights of trees.

MATERIALS:

Measuring tape
Worksheet

PROCEDURES:

There are several approaches that can be used to measure the heights of trees. Students will explore the *Indian Method.*

A measuring tape should be placed vertically on a wall starting at zero at the base of the wall and increasing vertically with increments measured in feet. A second measuring tape should be placed moving away from the base of the wall with increments measured in feet. (Computer paper makes a good wall ruler.) Several students who can touch their toes with their legs spread will be asked to walk away from the wall to varying points on the tape, bend over, hold their ankles, look between their legs, and tell what the highest number on the wall is that they can see. These students will be the class "rulers". It's fun to see who the best ruler is.

Students will then break into groups of two or three and discuss these findings. If there is a pattern, they are to identify the pattern and see if it can be used to answer questions about measuring the heights of trees or other objects.

The worksheet provided will give some idea as to how the worksheet might be formed.

CLOSURE:

Students will report back to the whole group on what they found. The teacher will try to have the students synthesize the reports.

EVALUATION:

Students working in pairs will be asked to measure the height of an object of special interest to them around the school and report on how they measured it.

Worksheet: Measuring the Heights of Trees

Measuring the heights of trees is a necessity in the forest industry. There are precise instruments that can perform that task. For the amateur, however, this activity will help us learn about a new measuring device, our own bodies. Measuring in this way is called the *Indian Method.*

1. Fill in the table below with the measurements found by the class rulers using the *Indian Method* as described below:

    a. Move out to the mark on the floor ruler with your back to the wall ruler.

    b. Straddle your legs shoulder width apart, reach down, and grab you ankles.

    c. Drop your head and look up between your legs.

    d. Register the highest point you can see on the wall ruler without moving your head.

    e. Do this at the 3 foot, 6 foot, 9 foot, and 12 foot marks from the wall.

Heights Seen by Students

Distance from wall	Student 1	Student 2	Student 3	Student 4	Student 5
3					
6					
9					
12					

2. Explain if there is any pattern to the numbers.

3. What would you predict the height seen by the student to be if the student were 20 ft. from the wall? 30ft.? 100ft.?

4. Can you use this to make a plan to measure the height of a tree?

5. Can you explain how and why this method of measuring heights works? (A diagram showing the problem may be helpful.)

Urban Critters

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Thomson, Barbara S. (1984). *COSI Urban Workshop Activities.* Unpublished workbook.

MATHEMATICS STANDARDS:

Computation and Estimation
Problem Solving
Probability

OBJECTIVES: The students will learn:

1. Estimation skills.
2. To collect a random sample.
3. To respond to an environmental question using mathematic techniques.

ACTIVITY:

BACKGROUND:

Information about populations in a given area is often important for a variety of reasons. How many cockroaches are living in my house? How many ants invaded my kitchen? What is the population of worms in my garden? Information is often needed for useful organisms as well as the ones we consider a problem for humans.

Some organisms are viewed as pests by people but necessary for life by other creatures. Each year the purple martins fly from Brazil to the United States to nest and raise their young. They consume approximately 5000 mosquitos each day. For the purple martin the mosquito is a necessity.

Estimating a given population is a technique used by scientists and technicians to assess the approximate number of organisms in a given area. We are going to determine a population using this process.

How can we discover the population of urban critters in our study area? Discuss random samples. Demonstrate tossing the cardboard square and counting the different kinds of urban critters under the square. Toss the square 9 times and average each of the sample totals.

Example: (On four tosses of the square, you register 6, 7, 3, and 2 black turtles.)

1. Average black turtle critters: 6 + 7 + 3 + 2 = 18/4 = 4.5
2. Multiply the average by the total number of squares in your plot to determine the urban critter population.
3. Make a graph or data chart to summarize your information mathematically.
4. Combine all the data from each group and do a summary.

MATERIALS:

Beans—a wide variety (turtle, pinto, navy, split peas, etc.) these are urban critters
Grassy *or* wooded area with leaves and mulch
Clipboard
Meter stick
String
4 nails to create a square meter area
6 x 6 centimeter cardboard square

PROCEDURE:

Divide students into pairs for cooperative learning. Go outside and measure an area so each pair has one square meter to study. Each group will count one bag of urban critters (such as turtle beans) and distribute their critters in the total study area. At the end of the study we shall be able to demonstrate the effectiveness of the technique used to gather data.

When all the critters have been distributed in the study area, go to your measured space and proceed with your study as illustrated in the example.

CLOSURE:

Share the graphs and summaries with everyone in the classroom. Also share the total critters placed in the habitat by each group. Discuss the accuracy of sampling techniques, advantages and disadvantages.

EVALUATION:

Invite a speaker to class from a local pest control company. How does a business estimate urban organisms? If you did this activity again, how would you design it? Be specific.

How would you determine the population of your school, including the urban critters in your building?

When It Rains It Pours

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Thomson, Barbara, S. (1990). Columbus Zoo Rainforest Workshop. Unpublished workbook.

MATHEMATICS STANDARDS:

Mathematics as Communication
Statistics
Patterns and Functions

OBJECTIVES: The students will learn:

1. To collect data from reading scientific articles.
2. To identify data that could be reported mathematically from scientific books, articles, etc.
3. To summarize and report environmental data mathematically.
4. To use mathematical communication skills to enhance the scientific literacy of citizens about reasons for concern for the rain forests.

ACTIVITY:

BACKGROUND:

Global warming and the elimination of the tropical rain forests of the world are important topics in school, on television, and in the news. What kind of data are really important about the rain forests? How might it be reported in an interesting mathematical way to educate the public?

MATERIALS:

Paper and pencil
Library resources

PROCEDURES:

Students will work alone or in cooperative groups to identify rain forest topics to research. The focus will be on the tropical rain forests and the impact on the rest of the world as the rain forests are eliminated.

Students will read and develop a topic that can be used to educate the public. Developing ways to communicate the vast amount of data available will be the challenge. Students should remember that their task will be to educate the general public about the rain forests. Accurate and interesting ways should be explored.

CLOSURE:

Make a poster to communicate your mathematical information about the rain forest. The poster should have accurate information and capture the attention of the intended audience.

EVALUATION:

Critique each other's posters and write a brief summary of the strengths, weaknesses, and suggestions for improvement.

POPULATION DESCRIPTION AND GROWTH

Estimating the Environment

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education.

REFERENCES: National Science Foundation. (1965). *Elementary Science Study.*
National Council of Teachers of Mathematics. (1989). *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author.

MATHEMATICS STANDARDS:
Computation
Estimation

OBJECTIVES: The students will learn:

1. To increase their estimation skills.
2. To develop techniques for estimating the number of organisms in their environment.

ACTIVITY:

BACKGROUND:

Estimation should be used on a daily basis. In order to enhance the transfer of this standard, many opportunities must be available to use estimation and computation. Being able to estimate can assist people in a wide variety of settings each day. This activity utilizes simulated habitats in local zoos, nature centers, or aquarium shops to develop and create estimation skills.

MATERIALS:
Clip board to use at the field site (zoo, nature center, aquarium shop, ant hill, farm, etc.)
Paper and pencil
Calculator (optional)

PROCEDURES:

The students will visit a zoo, nature center, or aquarium shop. Any exhibit with numerous organisms can be used as the first exposure. The students look at the exhibit and estimate the number of organisms.

They write down their estimate and then proceed to count the animals. It is important to spend time after this first encounter in discussing ways they tried to estimate. Sharing techniques will illustrate numerous ways to estimate.

Have the class divided into groups of three students. Ask them to estimate the total number of animals in the aquarium, the reptile house, or the entire zoo depending upon how they are progressing with the development of their estimation skill.

Have the students write down their estimation techniques and justify how they arrived at their answers. Each group will estimate the same items.

CLOSURE:

It is crucial that the learners have an opportunity to share their estimations and techniques prior to leaving the site. Reserve a meeting area to have this discussion. Thus, any controversy can be reviewed by redoing the estimation with student evaluators. It is important to remember that estimations are not exact but are within certain parameters.

EVALUATION:

Have each group write their directions for estimation in a particular site. Exchange directions and try to use another group's techniques. Discuss the results and the strengths and weaknesses of each technique. Have the students design instructional worksheets for others to use.

Explore Population Growth Via Spreadsheets

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education.

REFERENCES: Wells, G. & Berger, C. (1986). Teacher/student developed spreadsheet simulations: A population-growth example. *Journal of Computers in Mathematics and Science Teaching, 5* (2), 34-39.

MATHEMATICS STANDARDS:

Patterns and Functions
Numbers and Number Relationships

OBJECTIVES: The students will learn:

1. To use spreadsheets to generate values in an iterative process.
2. To identify the factors that affect exponential population growth.
3. To determine the shape of the graph of a population-growth problem.
4. To vary in a spreadsheet the different effects of the variables affecting population growth.

ACTIVITY:

BACKGROUND:

The issue of population growth is the backdrop to study the concept of a recurrence relation through the medium of spreadsheets. A recurrence relation is one in which subsequent values depend systematically on previous values. Although normally covered in the NCTM *Standards* for grades 9-12 on discrete mathematics, the use of a spreadsheet makes the concept accessible to middle-grade students. The spreadsheet can be used to explore numerical relationships, such as exponential growth as exhibited in population growth.

The teacher will need to discuss the concept of how mathematics can be used to describe population growth. Students will need to identify the main variables when describing the growth of a population. It will be interesting for the students to see the effects of varying the factors of initial population, rate of increase, and time, both in the table of values and respective graphs.

MATERIALS:

Personal computer (IBM-PC, Apple, etc.)
Spreadsheet software (Lotus 1-2-3, AppleWorks, Microsoft Excel, etc.)
Worksheet

PROCEDURES:

Discussion of the issue of population growth should begin the lesson. Student discussion should bring out the factors that will affect population growth: (a) what population you start with, (b) what percent increase there is, and (c) how long the population is growing. At this level, the emphasis will be less on the algebra of the relationship and more on the nature of the relationship. The basic mathematical relationship is:
New Population = Starting Population + a percentage of the Starting Population.

A spreadsheet is an effective tool that will allow students to explore this relationship by changing values for the given parameters involved in the relationship and looking for the effects that these changes have.

Figure 1 gives an example of the formulas that could be put into the cells of the spreadsheet, allowing students to explore the relationship. One class will probably be needed to help the students understand how this relationship can be represented using a spreadsheet. After entering the rate of increase in cell B2 and the starting population in cell C2, the formula: +C2 + C2*B2 to represent the new population would be entered into cell C3. This process will naturally introduce the concept of variable without excessive attention drawn to that fact.

Students are now ready to explore the relationships via the spreadsheet. Students can work in groups according to computer availability. Diskettes should be ready so that students can get directly to the spreadsheet. Figures 2, 3, and 4 show spreadsheet output when values are given to the different parameters. Students will be excited to see the power they have in changing the numbers and observing the effects. The worksheet will then be provided to channel some of this energy to help extract the relationships present.

CLOSURE:

Students will be asked to report on their findings on how the initial population, rate of increase, and time affect the population growth problem.

EVALUATION:

Students will be asked to identify what aspect of this relationship is controllable by people, and to suggest ways that a zero population growth can be achieved.

Spreadsheet Figures

	A	B	C
1	TIME	RATE	POPULATION
2	0	0.12	1000
3	=A2+1	=B2	=C2+B3*C2
4	=A3+1	=B2	=C3+B4*C3
5	=A4+1	=B2	=C4+B5*C4
6	=A5+1	=B2	=C5+B6*C5
7	=A6+1	=B2	=C6+B7*C6
8	=A7+1	=B2	=C7+B8*C7
9	=A8+1	=B2	=C8+B9*C8
10	=A9+1	=B2	=C9+B10*C9
11	=A10+1	=B2	=C10+B11*C10
12	=A11+1	=B2	=C11+B12*C11
13	=A12+1	=B2	=C12+B13*C12
14	=A13+1	=B2	=C13+B14*C13
15	=A14+1	=B2	=C14+B15*C14

Figure 1. Spreadsheet formulas

	A	B	C
1	TIME	RATE	POPULATION
2	0	0.12	1000
3	1	0.12	1120
4	2	0.12	1254
5	3	0.12	1405
6	4	0.12	1574
7	5	0.12	1762
8	6	0.12	1974
9	7	0.12	2211
10	8	0.12	2476
11	9	0.12	2773
12	10	0.12	3106
13	11	0.12	3479
14	12	0.12	3896
15	13	0.12	4363

Figure 2. Spreadsheet Sample 1

	A	B	C
1	TIME	RATE	POPULATION
2	0	0.12	1000
3	1	0.12	1080
4	2	0.12	1166
5	3	0.12	1260
6	4	0.12	1360
7	5	0.12	1469
8	6	0.12	1587
9	7	0.12	1714
10	8	0.12	1851
11	9	0.12	1999
12	10	0.12	2159
13	11	0.12	2332
14	12	0.12	2518
15	13	0.12	2720

Figure 3. Spreadsheet Sample 2

	A	B	C
1	TIME	RATE	POPULATION
2	0	0.12	2000
3	1	0.12	2160
4	2	0.12	2333
5	3	0.12	2519
6	4	0.12	2721
7	5	0.12	2939
8	6	0.12	3174
9	7	0.12	3428
10	8	0.12	3702
11	9	0.12	3999
12	10	0.12	4318
13	11	0.12	4663
14	12	0.12	5036
15	13	0.12	5439

Figure 4. Spreadsheet Sample 3

Worksheet: Population Growth—What makes it go?

Population increase is a problem that we face in today's world. Understanding how and why it increases will help us solve the problems that we face. Using the spreadsheets and the graphs they make will help us understand population growth. These questions will help lead your exploration:

1. A town of 1000 people is facing a population increase that might require new schools in 10 years if the population goes high enough. Does it make much difference if the rate of increase is, 2%, 4% 6%, or 8%? Use your graphs to make your argument.

2. At an increase of 8%, how long does it take to double the population of a town if the population starts at 1000? 10,000? 50,000? Discuss the different problems towns with these populations will face.

3. About what rate of increase would you need for a population to triple in 15 years?

4. To solve problems about populations, what do you think is the most important thing to know? Why?

Going, Going, Gone!

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Local zoos, nature centers, museums, libraries, and State Department of Natural Resources.

MATHEMATICS STANDARDS:

Probability
Mathematics as Communication
Mathematical Connections

OBJECTIVES: Students will learn:

1. That some animals are extinct in their state but still live in other places in the world.
2. To make predictions how long certain animals will continue to live in a certain area.
3. That data are available on the populations of animals.
4. That data can be used to increase their understanding of population changes and predictions.

ACTIVITY:

BACKGROUND:

The teacher will need to collect materials on endangered animals and extinction from the State Department of Natural Resources and the local library. Many students believe that the elimination of species is occurring in other countries. They have no historical perspective to help them realize that some animals were residents of the state in which they live and are now extinct in that state. Population data are available from the state fish, wildlife, and natural resource offices.

MATERIALS:

Statistics and probability information from your State Department of Natural Resources
Available library materials
Library videotapes on endangered and extinct animals
Natural histories available from your State Department of Natural Resources on different state animals.

PROCEDURES:

1. Show a video tape on endangered and extinct animals with the entire class. Have cooperative learning groups review the printed materials and make a list of animals from your state that are gone or decreasing in number.
2. Ask pairs of students to sign up to do a research report on the status of a particular animal on the list. The paper should include data and graphs showing population changes and predictions.
3. Have each pair of students prepare an audiotape on a particular animal to share with parents and other classes. The tape should include what can be done to bring back this animal into your state or increase the population on declining animals.

CLOSURE:

Have students obtain reactions to the tapes from both adults and other classes. Request reasons for decisions from these people. For example, some people may not want the return of wolves or bears to a particular area as they consider such animals dangerous to humans or domesticated animals who live there.

EVALUATION:

Have each pair of students develop a quiz for their tape with ten questions. Have them administer the quiz to adults at school and at home or to other classes and determine what was learned by these people. Have each pair also evaluate another group's tape and make suggestions to improve this presentation. Each group will meet and decide what needs to be changed and to make modifications to improve the tapes.

Life Zones

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Hansen, M. (1991). The life zones. *Mathematics in School, 26*(1), 34-37.

MATHEMATICS STANDARDS:

Geometry
Problem Solving
Patterns and Functions

OBJECTIVES: The students will learn:

1. To draw diagrams representing successive stages of lifeform growth.
2. To form number patterns to describe cell populations at successive stages of lifeform growth.
3. To predict cell populations at future stages and represent their predictions algebraically, if appropriate.

ACTIVITY:

BACKGROUND:

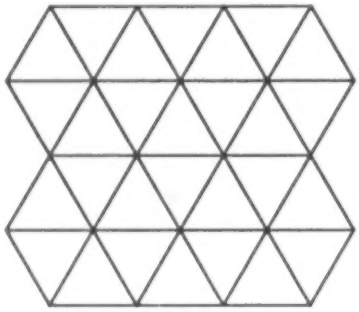
The topic of growth is one that students can easily relate to as they observe the world around them. As middle school students, they probably are experiencing periods of physical growth that intrigue and confound them. In the area of environmental studies, population growth is only one of many areas to which this concept can be applied. "Life Zones" provides an alternative to exponential growth in studying this phenomenon. This approach incorporates several varying factors that affect growth. The factors that affect "cell" growth are:

1. cell shape,
2. initial lifeform "seeds", and
3. rules to determine the "birth" of new cells.

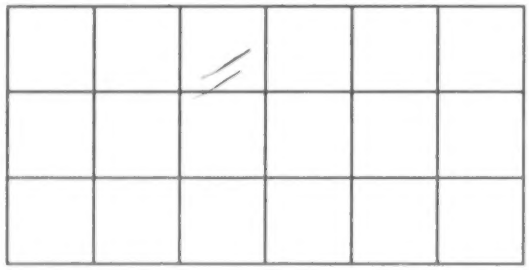
For the purpose of this activity, we will only describe the most simple cases of cell type and growth patterns, leaving the reader to invent newer lifeforms on their own or referring to Hansen (1991) for his suggestions.

Cell Shapes: The three cell shapes used here are:

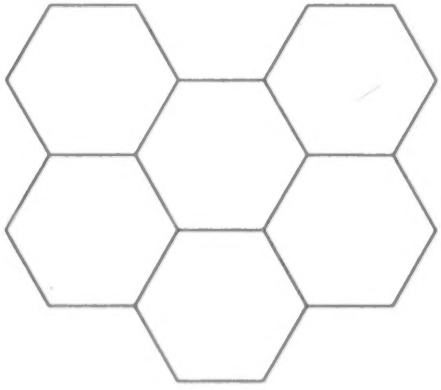
1) Equilateral Triangle



2) Square



3) Regular Hexagon



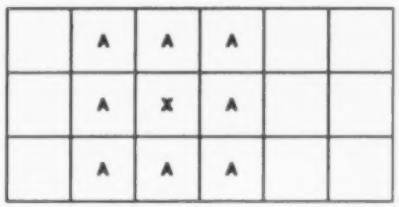
The cell marked **X** would be considered the initial life form, with growth taking place in adjacent cells.

RULES FOR BIRTH:

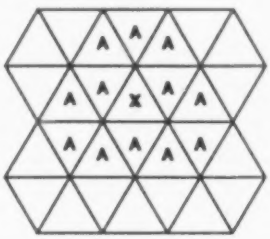
1. Life Growth Type A: All adjacent cells come alive.

   The examples below indicate which cells would come alive at the next time increment if cell **X** is alive.

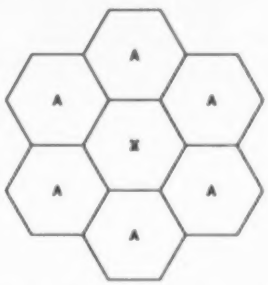
   Square:



   Equilateral Triangle:



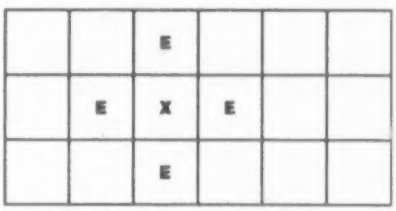
   Regular Hexagon:



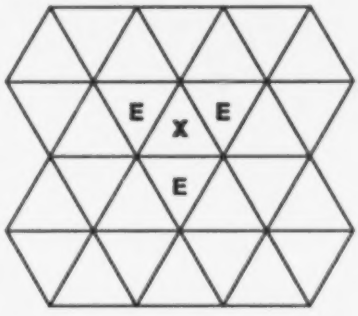
   Cell X comes alive if any one or more of the surrounding cells is alive.

2. Life Growth Type E: If Cell X is alive, then cell E comes alive in the next time increment.

   Square:



Equilateral Triangle:



MATERIALS:

Gridsheets with squares, equilateral triangles, and regular hexagons
Colored pencils or markers to indicate sequential stages of growth
Worksheets to identify initial life forms
Calculators

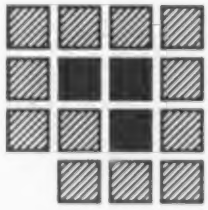
PROCEDURES:

Once the students have been introduced to cell shapes and growth types, they can experiment with growth patterns of different life forms. The following example can be presented to the full class followed by group explorations of different life forms. The following lifeform can be given on the overhead projector on a grid of squares.

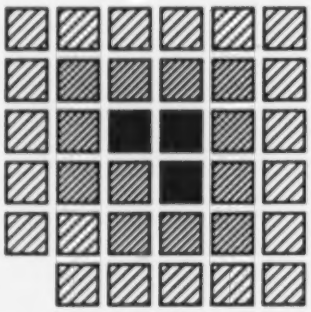
Lifeform "3S" Seed: Using Life Growth Type A we see:

at t=0:

at t=1:



at t=2:



Putting this information and information from subsequent stages into a table, we obtain:

Time Stages	# of New Cells	Total # of Cells
t=0	3	3
t=1	12	15
t=2	20	35
t=3	28	63
t=4	36	99
t=5		

The students can be challenged to predict the number of new cells at the next stage t = 5 and also for future stages, such as t = 10. At this point they can use both the number pattern emerging from the table or the geometric pattern from the successive figures. The pattern of adding eight more new cells at each increment can be observed, making it easy to predict the number of new cells. However, at t = 10, it might not be as easy to predict the total number of cells without going through each successive stage. An appeal to the observation that the new figure is always a square with one cell left out of one corner might make that task easier.

To check their predictions, the students can break up into small groups and try to solve the problem. Calculator use can be encouraged at this stage of the lesson. Depending on the level of the student, the teacher can assign subsequent tasks to look for an algebraic expression that would generalize their findings, or let the students present arguments to verify their findings. The sheet provided gives examples of other "seeds" that could be explored by the students.

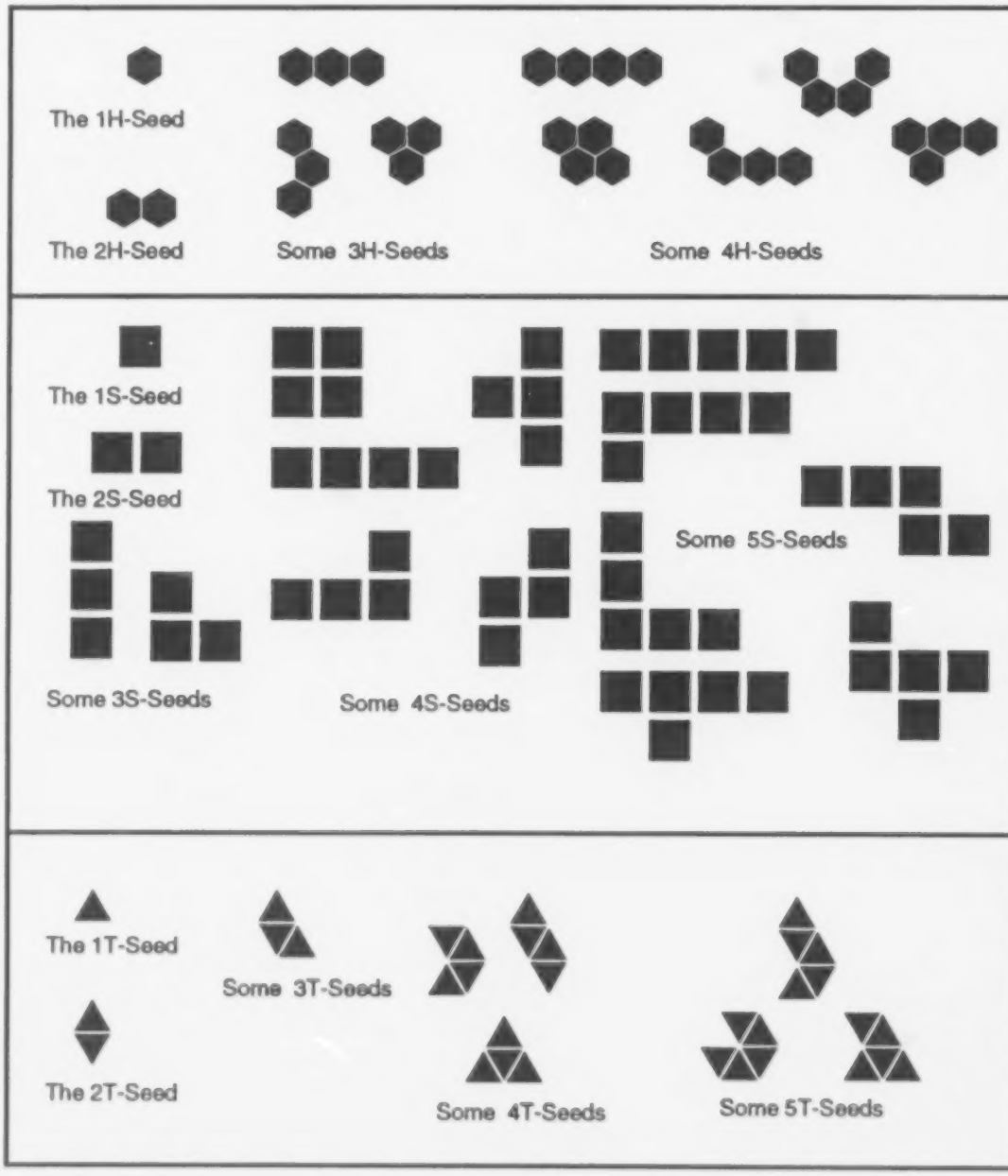
CLOSURE:

Students can reconvene as a large group to discuss the results of the growth patterns in the lifeforms explored. Applications such as city planning, where the city's growth would model cell growth, could be discussed.

EVALUATION:

Students can be asked to imagine other phenomena that would be modeled by the lifeform growth studied.

Example Seeds



Checkerboard Mathematics

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education.

REFERENCES: Allen, R. F. (Ed.). (1983). *101 ways to teach about exponential growth and its consequences.* Sebring, FL: Tri-County T Ed. Center. (ERIC Document Reproduction Service No. ED 225 856)

MATHEMATICAL STANDARDS:
Number and Number Relationships
Patterns and Functions

OBJECTIVES: The students will learn:

1. To develop understanding of powers of a number through a population-growth problem.
2. To develop notation to express powers using exponents.
3. To use calculators to explore the number patterns generated by successive powers of a number.
4. To explore what consequences population growth would have on the depletion of energy resources.

ACTIVITY:

BACKGROUND:

The introduction of exponents is often handled by stating definitions and giving examples of their use. Exploring this concept in the context of a population-growth problem will make its importance more meaningful.

Secondly, the example of the rice on the checkerboard will give a concrete example of what occurs when a quantity is doubled successively. Students will see that their intuition with respect to the effects of doubling is different from the actual phenomenon. Seeing what actually happens will open the door for significant discussion on issues like population growth, natural resource depletion, pollution levels, or quantities that may grow or decrease exponentially.

MATERIALS:

Partners
Calculators
Worksheet
Rice and checkerboard.

PROCEDURES:

Begin the class with discussion of how the population is growing rapidly. Give statistics that show how the population of the U.S. (you could use your state, county, etc.) has doubled in a certain period of time. Ask the class when is the next time that the population will be doubled, if it took the same amount of time to double. What would the population be?

Distribute worksheet, the rice checkerboard and 1 cup of rice. The students should pair up to work cooperatively. The use of calculators is encouraged in this situation.

CLOSURE:

Reconvene the class in a large group to discuss the student's findings. Use the answers from question 4 to explore the pattern to these numbers.

Ask the class to determine if that pattern of numbers can be written down in a mathematical sentence.

For example: Square 3 = 1 x 2 x 2.
Square 6 = 1 x 2 x 2 x 2 x 2 x 2

Use this pattern to introduce exponential notion.

EVALUATION:

Have the students write in their mathematics journals what they think would happen if the population were to triple for each period of time.

Worksheet

1. Use the table below to keep track of how much rice is in each square in the Rice Checkerboard provided.

Square	# of grains of rice
1	
2	
3	

   a) In square 1 place one grain of rice.
   b) In square 2, place twice as much rice as the amount in square 1.
   c) In square 3, place twice as much rice as the amount in square 2.
   d) Do this same thing up to square 5.

2. Estimate how many grains of rice you will need to complete the checkerboard. Will the amount given be enough?

3. Were you able to fill the board?

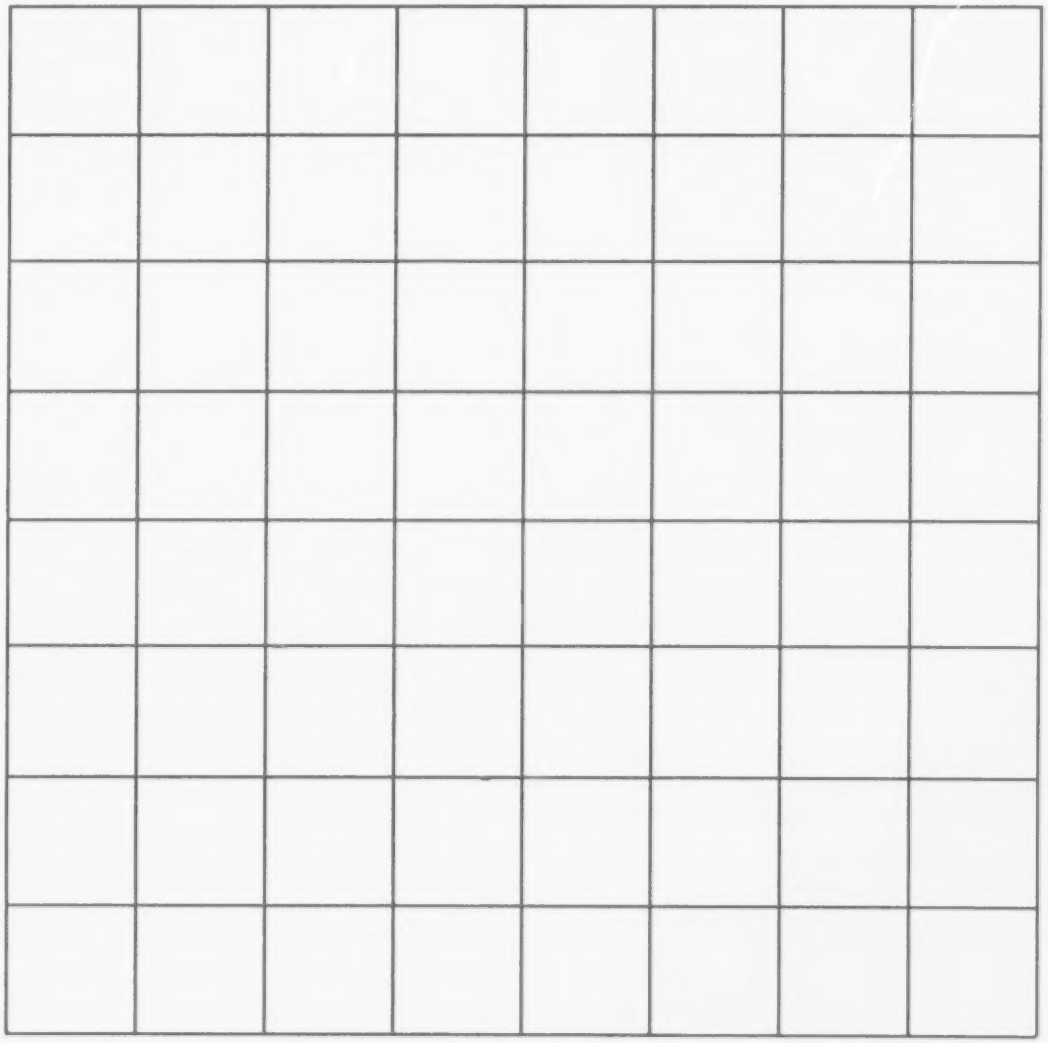
4. Is there a pattern to the numbers in each successive square? If so, can you explain how it works?

5. Can you write down a math sentence that calculates the amount in square 3, square 6, square 64?

6. What will happen if the population grows like this?

7. If the population in our community grows in this way, name some things in our lives that will be affected by that growth.

Checkerboard



What's Your Opinion?

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Showalter, V. (1992). *Science and technology for the university core.* Columbus, OH: Capital University.

MATHEMATICS STANDARDS:

Mathematics as Communication
Statistics

OBJECTIVES: The students will learn:

1. To gather data through interview techniques.
2. To use statistics by averaging responses.
3. To summarize and analyze data using statistics.

ACTIVITY:

BACKGROUND:

Communication is important in order to learn new information and to review existing information. Talking with other people is a way to gather additional information. One area of communication that is very useful is public opinion. People have opinions on a wide variety of topics. This activity explores opinions people have about the environment using a student-designed questionnaire.

MATERIALS:

Clipboard and pencil
Questionnaire
Objective attitude as an interviewer
School library

PROCEDURES:

1. Divide into pairs for this activity. One student can write the answers to the interview questions while the other student asks the questions. Take turns so both of you have an opportunity to experience the two tasks.

2. Watch a news program or a local talk-show on television. What kind of questions do they ask? Do they ask questions that can be answered by a simple yes or no?

3. What kind of environmental issue would make a good topic? Look in your local newspaper and watch a news program on television. Each community has local issues dealing with the environment that would be a good focus for your questionnaire. Is your community short of water, seeking a landfill site, trying to establish a recycling program, or experiencing more air pollution alerts? There are many environmental topics that are important to explore. Select a topic that is of interest to your own community.

4. Developing a questionnaire requires good questions and a short period of time needed to interview the various people. Most subjects will not want to spend lots of time answering your questions. Recording their answers needs to be done in an efficient way, too.

5. After selecting an interesting topic, work with your partner to develop a questionnaire that will help you to explore the areas needing information. Practice with your questionnaire on your own classmates. They will help you to improve it and you can help them to improve their questions.

6. Interview at least 12 people. You might decide to interview only people on your block or only people who visit your home. Make a decision with your teacher on how to select the people you will interview.

7. Once you acquire the information from your interviews, you will need to count similar answers and discover how people feel about their topic. Counting the number of "yes" responses, the total can be placed on a graph and compared to the number on "no" responses. Visit your school library and look in some simple statistics books to explore additional ways to communicate this information.

CLOSURE:

Prepare charts, graphs, etc. to share with the other class members. Discuss the strengths and weaknesses of the interview techniques.

EVALUATION:

How would you redesign your questionnaire? What were the weaknesses and strengths of your questionnaire? How might you improve the questionnaire to avoid some of the weaknesses?

When Will It Double?

LEVEL: Grades 7-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Schultz, J. M. & Coon, H. L. (1977). *Population education activities for the classroom.* Columbus, OH: ERIC Clearinghouse for Science, Math, and Environmental Education. (ERIC Document Reproduction Service No. ED 141 178)

MATHEMATICAL STANDARDS:

Patterns and Functions
Number and Number Relations
Estimation

OBJECTIVES: The students will learn:

1. To use the exponential growth relationship to examine how long it will take for a population to double.
2. To compare the impact of different birth rates on the amount of time it takes to double a population.

ACTIVITY:

BACKGROUND:

The world has a limited amount of resources. Because the world's population continues to grow, the question of how long the resources will last largely depends on how fast the population will grow and whether new resources can be discovered.

The mathematical relationship needed for this activity involves adding a percentage of a number to itself. This can be represented by the formula:

New Value = Original Number + a percentage of the Original Number

Letting N = New Value, O = Original Number and r = % rate of change, we have;

$$N = O + \frac{r}{100} \times O$$

Using the distributive property, this expression can be written:

$$N = O\ (1 + \frac{r}{100})$$

MATERIALS:

Calculators
Worksheets

PROCEDURE:

1. Discuss the issue of population growth with the class. Make sure that the students understand what increasing a population by a certain percentage would mean.
2. The calculator can be very useful in this example. Features like a constant key or an add-on percent key would be most helpful. For example, the TI31 (Texas Instrument's Scientific calculator) will add a percentage (5%) of a 1000 to itself to give the result 1050.
3. Doing this repeatedly will allow students to see doubling occur. Repeated multiplication by 1.05 will accomplish the same task. The exponent key can also be used to do these calculations. The teacher will need to decide on the appropriate calculator and method of calculation.
4. Hand out the worksheets with the information about population growth rates for several countries and continents.
5. Ask the class to estimate how long it would take for a village of 1000 people to double in size if it were in each of the countries or continents.
6. Divide the class into groups of 3 or 4 to work on the problems together. Answers should be recorded, and it should be made clear that answers need to be justified.

CLOSURE:

The full class should reconvene to discuss the results of the group work and determine if there are any patterns to the doubling of the population depending on the different rates used?

EVALUATION:

Given that the doubling time for a population increase of 3% is 24 years, each student should be able to estimate the doubling time for a population increase of another percentage and justify the answer.

Worksheet: When will the population double?

The table below gives you the rate of increase in population for several countries and continents around the world. First, **estimate** how long it would take to double the population of a town of 1000 in each area. Then **calculate** how long it would take to double the population.

Country	Rate of Population Increase	Estimated Doubling Time	Calculated Doubling Time
U.S.A	1.0%		
Russia	0.75%		
China	1.5%		
Africa	3.0%		
S. America	2.0%		
Kenya	5.0%		
Asia	2.5%		

1. How close were your estimates to the actual doubling times?

2. Was there any pattern to the rate of population increase and the amount of time it takes for the population to double?

3. If you know that it takes 24 years for a population to double when the rate of increase is 3%, would that help you estimate how long it would take to double at 2%?

4. Do the data frighten you or reassure you in any way? Why?

SOLID WASTE DISPOSAL

Dealing with Data

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Wiebe, A. (Ed.) (1984). *Down to earth solutions for mathematics and science.* (Book 6). Fresno, CA: Aims Education Foundation. (ERIC Document Reproduction Service No. ED 283704)

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

MATHEMATICS STANDARDS:

Statistics
Numbers and Number Relationships

OBJECTIVES: The students will learn:

1. The relationship between sample statistics and population statistics.
2. To make inferences from sample statistics to population statistics.
3. The relationship between sample size and the accuracy of inferences made on the population.

ACTIVITY:

BACKGROUND:

Recycling is currently an issue in the United States. Several states already have laws that require recycling of several items. The importance of this practice can be seen in its connection with energy conservation and solid waste disposal. This topic provides an interesting context from which to study how samples can be used to predict properties of an entire population.

MATERIALS:

Graph paper
Worksheets

PROCEDURES:

Begin with a discussion on why it its important to recycle. Finding out how many people recycle is also important. The worksheet will help students to understand the sample size necessary to estimate how many people are recycling in a given area:

1. Students will answer yes or no to whether or not their families recycle the four items: newspaper, aluminum cans, glass, plastic.
2. Each student will estimate the percent of the families in the class that recycle each of the items.
3. Divide the class randomly into groups of five students. This can be done by going down the class list alphabetically assigning students to groups. Once in their groups, students will fill in the column on the worksheet for a group of five students and plot the point that gives the percentage of students' families in the group who are recycling.
4. Next, the teacher asks 2 groups to join together to form groups of ten, completing the same task.
5. Following that, the teacher can choose groups of 15, 20, 25, up to 30 students, each time calculating the percentage of students recycling each item and plotting the corresponding values of the graph.
6. Once the entire class is plotted, the groups of five will be asked to interpret what happened to the samples as they moved closer to the total population. Students will determine if they need statistics from the whole class to get an accurate picture of the class.

CLOSURE:

Students will report to the class on their decision concerning how large of a sample size of randomly chosen students is needed to obtain an accurate estimate of how many people in the whole school recycle.

EVALUATION:

A sample of the entire school should be made by each group about the percent of students recycling. These findings will be compared to further examine the relationship between sample size and estimation accuracy.

Worksheet: Dealing with Data

1. Which of the following items do you recycle in your home?

   Glass? Aluminum? Newspaper? Plastic?

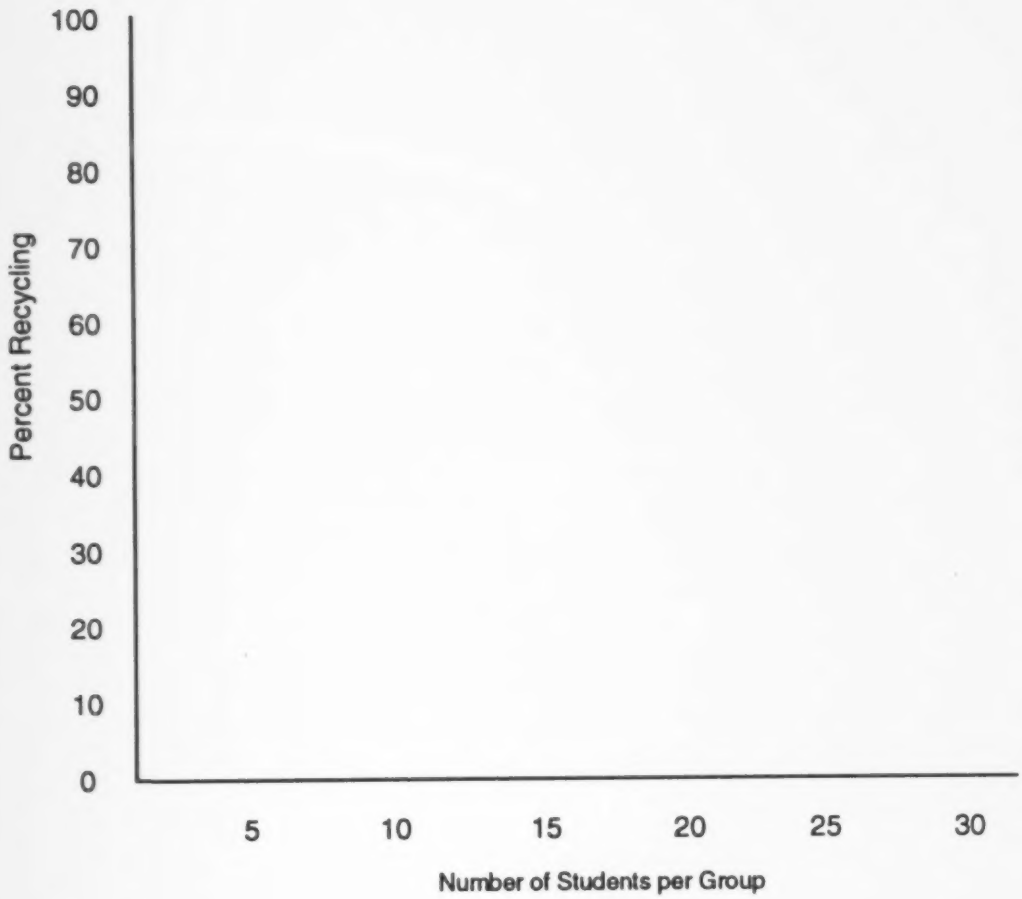
2. What part of the families in your school are recycling? Estimate what percent of the families in your class recycle glass, newspaper, aluminum, or plastic items.

   Glass? Aluminum? Newspaper? Plastic?

3. Using the information from your groups, fill in the chart below:

Items to be recycled	**Number of students per group recycling**					
	5	10	15	20	25	30
Glass						
Aluminum						
Newspaper						
Plastic						

4. Make a graph for each item that shows the relationship between the number of students sampled and the percentage of those students' families who are recycling that item. (Use a graph similar to the one below for each item.)



5. Answer the following questions in your groups of five:

   a) What percent of the whole class recycled:

      glass_____

      aluminum_____

      newspaper_____

      plastic_____

   b) How big a sample was necessary in order to come close to that percentage?

   c) Does this surprise you? Why or why not?

   d) If you wanted to know what percent of the whole school recycled these items, how big a sample would you have to take? Why?

The Landfill Dilemma

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Thomson, Barbara. (1991). The Landfill Dilemma. *The Young Scholars Teacher Orientation Workshop.* Columbus, OH: The Ohio State University.

MATHEMATICS STANDARDS:

Mathematics as Communication
Probability
Mathematical Connections

OBJECTIVES: The students will learn:

1. To explore the environmental question and make predictions.
2. To become knowledgeable about biodegradable materials.
3. To gain an understanding of our landfill challenge.

ACTIVITY:

BACKGROUND:

Each day numerous items are thrown away by everyone. We all create large amounts of trash everyday. Many times we believe that our trash will be buried and disappear into the earth over time. This activity will explore the probability of "breaking down" some common forms of trash by burying it in a simulated landfill.

MATERIALS:

Plastic bag
Nylon hose
Mesh vegetable bag used for onions in grocery stores
Plastic container (such as a margarine tub)
Scales

PROCEDURES: Divide into four groups.

1. Weigh out equal amounts of trash for the plastic bag, the nylon hose, the mesh vegetable bag, and the plastic container.
2. Include in these containers typical items, such as paper, dead vegetation (grass clippings), styrofoam cups, etc.
3. Be sure each amount has a similar mixture and weight.
4. Dig a hole or trench and place the containers in it with soil touching each side. Cover the bags with soil. Mark each site with a labeled marker.
5. What do you predict will occur?
6. In three weeks dig up your project.
7. Weigh the bags and examine the contents of each bag.

CLOSURE:

Discuss your results. Mathematics is often used to summarize data in a meaningful way. In what mathematical way could you communicate these results? Be creative.

EVALUATION:

Have students visit a landfill in your area or interview the directors of a landfill and tape record the answers. Another option is to use a speaker phone to have a teleconference call to explore this topic. Have students write in their journal their personal feelings about this topic.

Garbage! How Much Do We Create?

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education.

REFERENCES: Handlon, C. W. (1990). This lab is garbage! A "take home" activity. *The Science Teacher, 57*(5), 70.

MATHEMATICS STANDARDS:

Number and Number Relationships
Ratios, Proportions, and Percentages.
Geometry

OBJECTIVES: The students will learn:

1. To calculate percentages of total solid waste for any particular item.
2. To extrapolate from personal experience to predict solid waste quantities for greater populations.
3. To calculate volumes for containers.
4. To understand the implications of the solid waste disposal problem.

Activity:

BACKGROUND:

Solid waste disposal is a problem that is beginning to take on greater importance in many states where rising populations and diminishing disposal areas have presented a problem. Numerical analysis and geometry are needed to help understand and analyze this situation. This problem also provides the opportunity to get families involved in the students' education and help families realize their responsibilities in solving the problem. The Environmental Protection Agency in your area can supply you with data regarding disposal sites and the volume of solid waste disposed of in the area.

MATERIALS:

Trash containers
Graph paper
Surgical gloves or work gloves

PROCEDURES:

1. Discuss the issue of solid waste disposal with your students. Explain that during the next week, they will be analyzing the quantities of solid waste generated by their families. An appropriate letter to the parents of the students in the class will be needed to explain that in the coming week a study will be conducted about the solid waste in the students' home. (See Figure 1 for an example.)
2. Provide Worksheet 1 to the students to collect data for the week.
3. A part of the discussion in Step 1 above will include the ways to weigh the solid wastes and how their volume can be calculated. The volumes each student will calculate will depend on the type of container used in their homes. The most common will be either a cylindrical or rectangular shape, but others are possible. During the week, this problem will have to be resolved by the student.
4. Provide Worksheet 2 and have the students synthesize the data they've collected.

CLOSURE:

Have groups report back to the class on their findings and conclusions. A class average can be calculated and a graph of the data can be made.

EVALUATION:

Determine an environmental cause worthy of support and have the class determine how long it would take to raise $50 by recycling aluminum at 6¢ per pound. A similar challenge can be made to individual families.

Letter to Parents

Dear Parents,

Our mathematics class is exploring how we can use our mathematics skills to study the solid waste disposal problem. As part of this exploration, we are asking each child to collect data about what and how much trash is thrown away each week in their houses. Each student will be asked to separate all the trash that's thrown away starting Monday __, and ending Sunday __ into the following categories. Be sure your child is wearing gloves when sorting the trash.

Paper
Plastics
Glass
Aluminum
Metal
Miscellaneous

At the end of the week, we would like them to weigh each amount and calculate its volume. Would you please help with this effort? Thank you.

Sincerely,

Figure 1. Letter to Parents

Worksheet 1: This Lab is Garbage!

During the week starting Monday, ___, and ending Sunday, ___, you are to keep track of all the trash that is thrown out in your family household. You are to separate the trash into different categories:

Paper
Plastics
Glass
Aluminum
Metal
Miscellaneous

At the end of the week calculate the weight and volume for each category and record the information below.

Item	Weight	Volume (Cubic Feet)
Paper		
Plastics		
Glass		
Aluminum		
Metal		
Miscellaneous		

Bring the information to class with you on Monday, ____.

Find out what it costs per household to dispose of your solid waste!

Worksheet 2: Follow-up Questions Involving Collected Data.

1. How much solid waste was collected in one week per family? per person?

2. Can you predict how much would be collected in a year?

3. If a garbage truck can hold 5000 cubic feet of garbage, how many truck loads will your group produce in a year?

4. Do you recycle? If so, why? If not, why not?

5. How could recycling help your community?

TRANSPORTATION

Engineering a Bridge or the "Great Bridge Building" Contest

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: The Young Scholars Program. (1992). *Unified Science System.* Columbus, OH: The Ohio State University.

MATHEMATICS STANDARDS:
Geometry
Problem Solving

OBJECTIVES: Students will learn:

1. To use problem-solving approaches to investigate and understand mathematical content.
2. To develop and apply a variety of strategies to solve problems, with emphasis on multistep and nonroutine problems.
3. To verify and interpret results.
4. To acquire mathematical confidence.
5. To identify different mathematical shapes and understand their importance in the bridge-building process.

ACTIVITY:

BACKGROUND:

A bridge not only saves time in allowing a more direct route, but it also saves petroleum resources in motor vehicles. The importance environmentally is even greater than these two variables. A well-constructed bridge that will be appropriate for half a century utilizes natural and technological resources only once during that time instead of requiring numerous bridge replacements. Another important consideration is the disruption of natural habitats during bridge construction. Therefore, a well constructed bridge is very important to the environment as well as to society in general.

How does one build a bridge? Which variables are important? How important is the way the bridge looks? What geometric shapes are used most frequently to construct the strongest structure? Is the weight it will carry important?

MATERIALS:

Two packages of toothpicks
One container of bridge glue (Bottle of carpenter's glue)
Waxed paper
Paper towels
Enthusiasm and creative thinking

PROCEDURES:

Divide the class into pairs for this activity. Collaboration is very helpful in designing a structural model. Gifted students may want to work alone and this should be approved since this behavior is typical of gifted learners. Each pair will receive one set of materials and may not augment their bridge with additional materials. The question may arise about using the cardboard from the toothpick containers. That is all right but do not suggest it. This activity requires planning and designing strategies. The learners are challenged to build the best possible structure that will be tested for strength. Pictures may be useful and a discussion might be held to explore the different models. The identification of geometric shapes encountered in the different bridge structures is profitable at this time. Students should be encouraged to explore the relationship between geometric shape and bridge strength as they construct their bridges. However, students should not be limited to these models. They may have a more effective structure they would like to evaluate.

Students in cooperation with the teacher will also as a class design a way to test the strength of the bridges. A guide to testing the bridge is discussed below, but students may want to create a different way for each bridge to be tested. They also need to know that the bridges will be tested until they fracture. Some students may not want their bridge destroyed and will decide not to participate in the final contest.

Discussion issues prior to starting this project are:

1. Look at geometric figures. Which seem to be the strongest and most stable? Which ones appear most frequently in real construction projects? What shape appears the most in the bridge's framework?

2. Try to plan how you want to build your bridge in advance. Sketch how you want it to look. The glue will dry in several hours so that additional work can be done. However, the glue will be weak and tacky unless it has dried overnight.

3. MAKE SURE ALL OF YOUR GLUING IS OVER THE WAXED PAPER PROVIDED. If you need additional waxed paper, see your teacher.

Rules for the Contest:

1. The bridge must be built of materials supplied by the instructor (two boxes of toothpicks and one container of carpenter's glue).
2. The bridge must span one foot. This means that the bridge will have to be longer than a foot to be supported on either end.
3. The bridge must have provisions to be tested built into it. The test will consist of weights suspended from a block of wood. The block will be 1" x 2" x 4" and will be placed crosswise at the center of the span. The weights will be suspended on a rope hanging below the block and below the bridge.
4. The winning bridge will be based on the ratio of bridge weight to weight supported. This means that a light bridge may hold less weight than a heavy bridge but win because of the bridge weight to suspended weight ratio.
5. It should be noted that to test the bridge it will be necessary to destroy it. Otherwise, the weight cannot be determined. Students who become attached to their bridges and do not want to destroy them may withdraw their bridge from the contest after their bridge has achieved a 10 to 1 suspended-weight to bridge-weight ratio.

CLOSURE:

1. Explore local bridges and compare them to your own design. A field trip could be arranged to view both large and small bridges. Some bridges cross highways while others cross water. Keep a journal during the trip of your observation and comparisons.
2. Debrief after the bridge collapse session and review the process and the problem-solving skills used by the various learners.
3. Explore the geometric figures used in the bridge-building project and discuss the advantages and disadvantages.

EVALUATION:

1. Write a class article for the local newspaper and report this activity to the local readers. Submit it for publication.

2. Assign pairs to critique other partners' bridges prior to the bridge test. Have the evaluators predict the outcome of the bridge and give reasons for their ideas. After the bridge test, have the partners describe what occurred to that particular bridge and discuss why they were or were not accurate in their predictions. What design changes might have been useful for these partners to explore?

Bridge Building Information

I. What's a bridge?

A. Definition: Structure that allows the passage of traffic over a waterway, valley, road, or other obstruction-including another bridge.

II. Identification by:

A. Function: A bridge carrying water is called an aqueduct. A bridge carrying railroad cars or heavy traffic is called a viaduct. A bridge for pedestrians is called a footbridge.

B. Materials used in constructing a bridge include timber, masonry, concrete, reinforced concrete, iron, or steel.

C. Horizontal Members:

1. Beam bridges: constructed of long timbers, metal or concrete beams.

2. Girder bridges: deep, built-up metal beams. When this beam is in plate form, the bridge is called a plate-girder bridge. If the beam is replaced by a truss, beams (supports) are arranged in a triangular form, and the bridge is called a truss bridge.

D. Supporting structures:

1. Horizontal member resting on a vertical support or pier is called a simple bridge.

2. A continuous bridge has long horizontal members each supported on 3 or more piers.

3. Cantilever bridge is constructed so that the end of each horizontal member extends out past its vertical support.

E. Other methods include relative position of the bridge floor above or below its supporting structure and the manner in which its parts are connected (riveted/welded). Finally, bridges can be qualified by method used to provide clearance for traffic beneath them which is fixed or high level/moveable bridge.

III. History of Bridges.

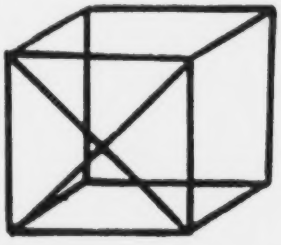
A. 5000 B.C.: Early man used fallen trees and stones to cross rivers, gorges, etc.

B. 2500 B.C.: Indian peoples developed the first suspension/cantilever bridge.

C. 900 B.C.: Mesopotamians developed first true arch bridge.

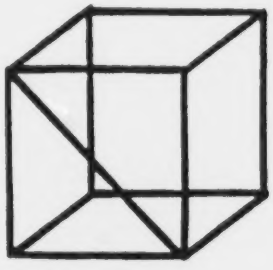
D. 621 B.C.: Romans built the first wooden bridge over Tiber River.

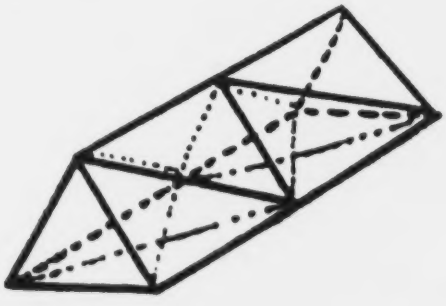
Useful Bridge Designs



X-Pattern

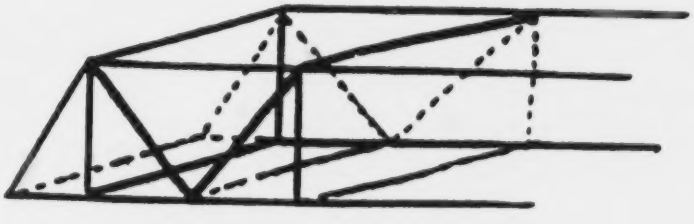
These cross members go on each face of the cube



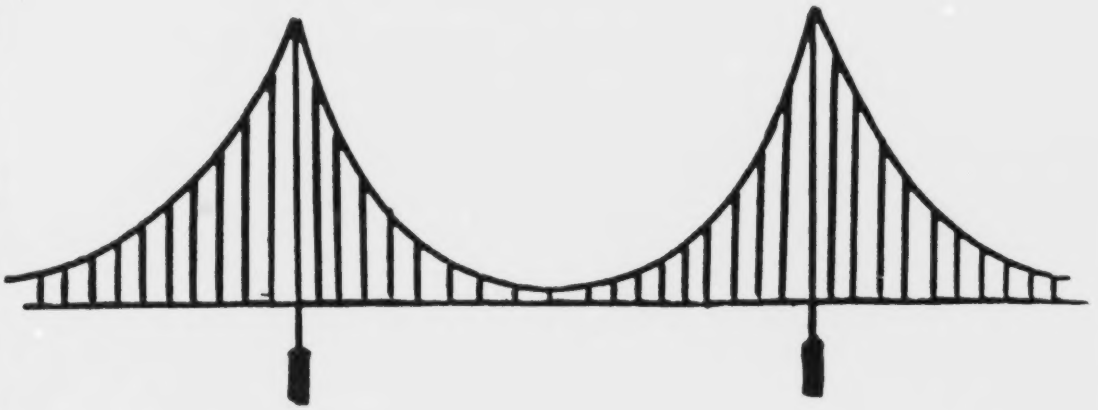


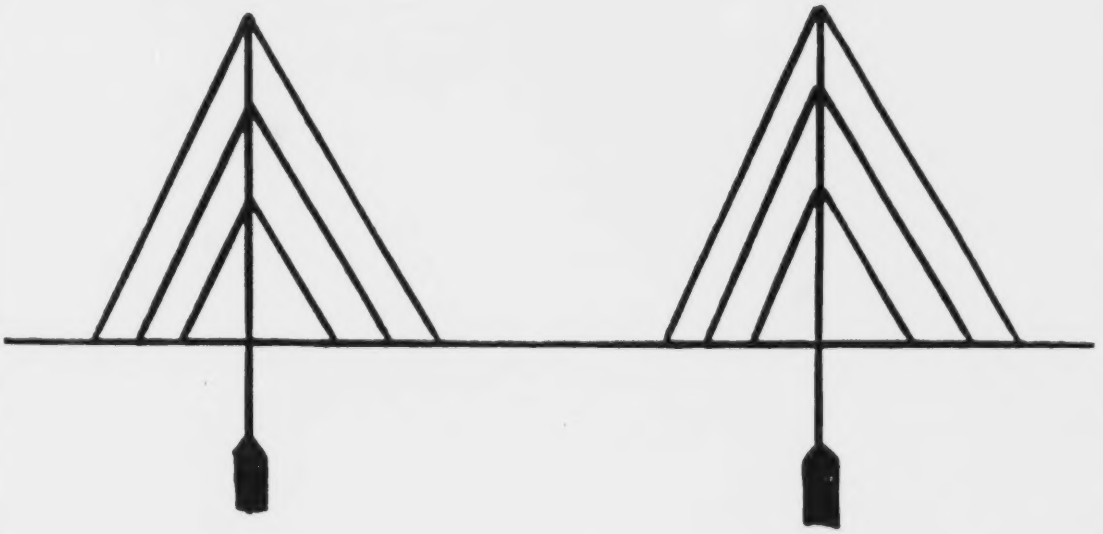
Diagonal Pattern

The diagonal cross members go on the face of each cube.

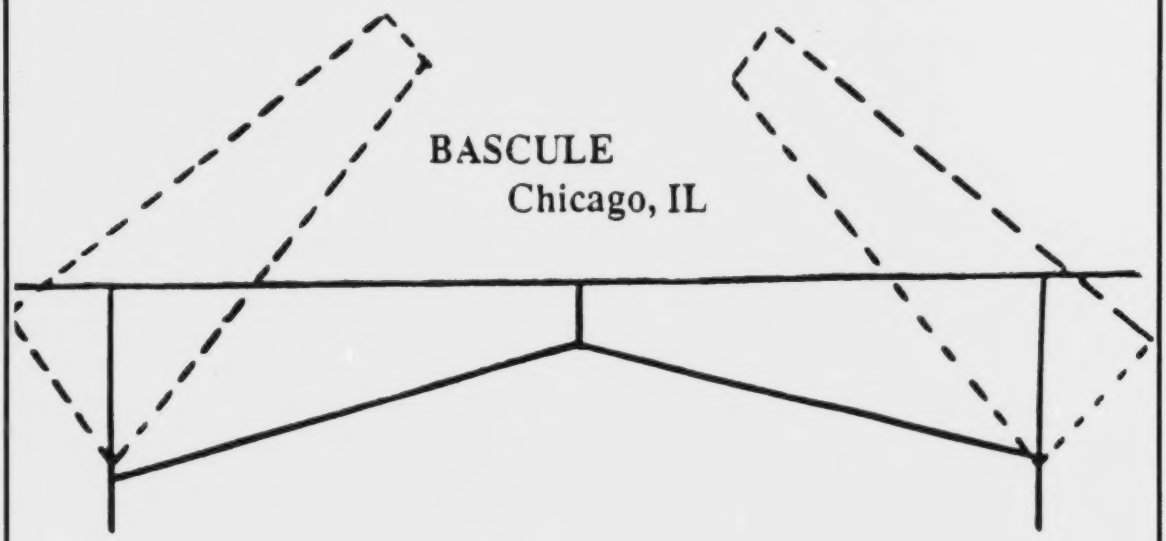


Suspension Bridges

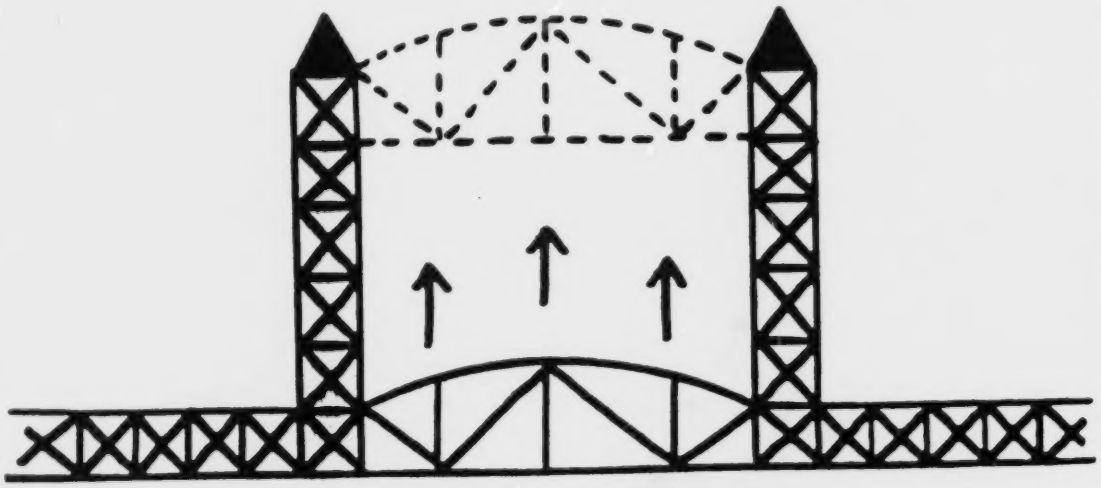




Moveable Bridges

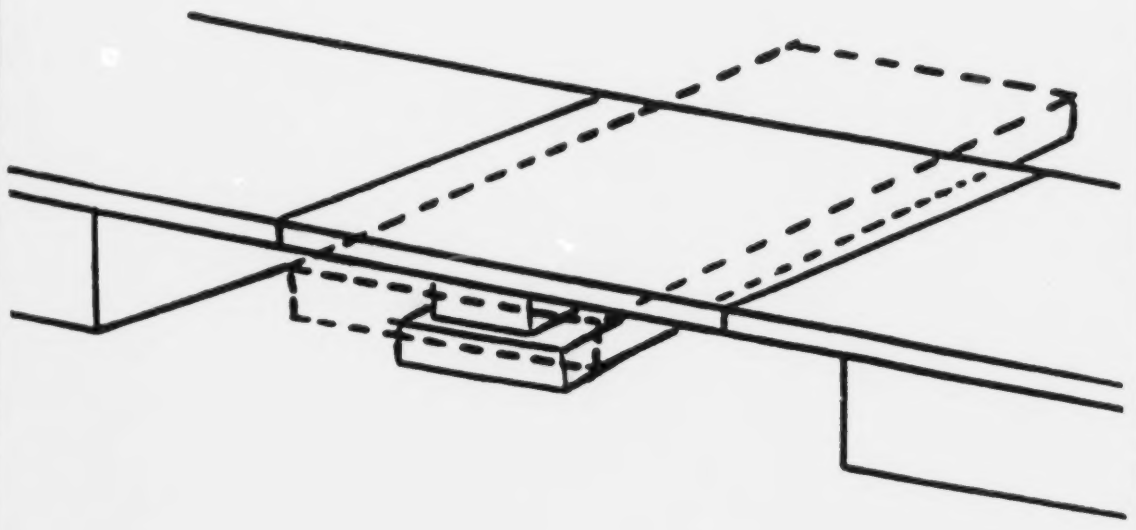


BASCULE
Chicago, IL

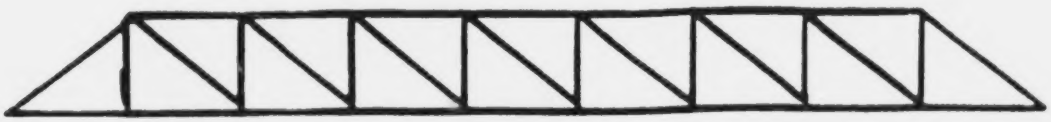


VERTICLE LIFT BRIDGE
Cape Cod, MA

Swing Span—Yorktown, VA

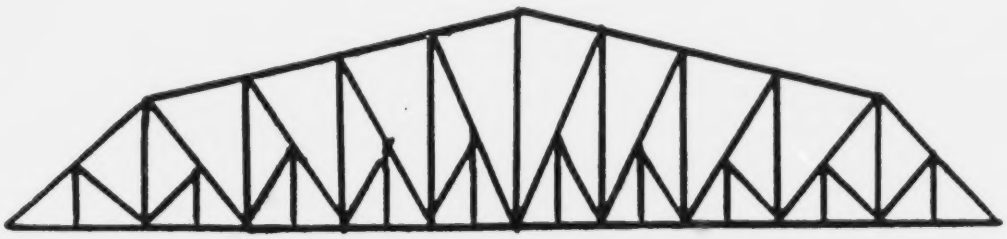


Bridge Types



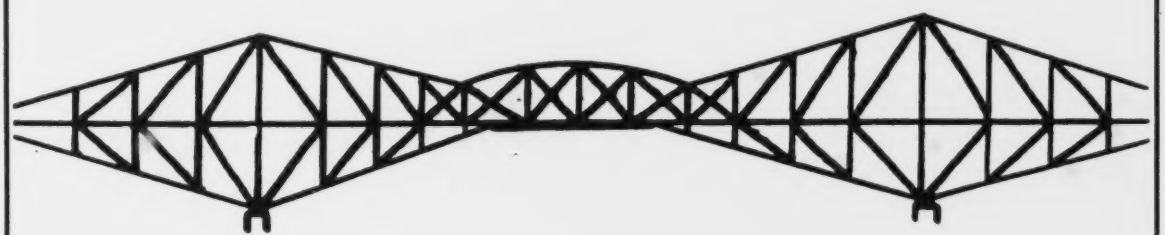
PRATT TRUSS

WARREN TRUSS



PETIT OR PENNSYLVANIA

Cantilever Bridge



From Here to There

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: EPA-Publications at State Offices. State Department of Transportation Public Relations.

MATHEMATICS STANDARDS:
Measurement
Problem Solving

OBJECTIVES: Students will learn:

1. To use mathematics to help explore transportation alternatives.
2. To expand their distance measurement skills.
3. To gain an appreciation of the relationships between transportation needs and the environment.

ACTIVITY:

BACKGROUND:

Going from one place to another is a challenge when any distance is involved. The Environmental Protection Agency (EPA) has pollution data illustrating the impact of combustion engine exhaust on our environment. However, we often individually forget the problems that the growth in the number of vehicles in this country causes for our environment. Seeking alternative ways to reach a destination means that options need to be explored. How can we go from here to there?

MATERIALS:

Clipboard
String and Tape Measures
City maps
Information from EPA and State Department of Transportation

PROCEDURES:

We often want to ask others to seek options when we have an environmental challenge. However, we should start with our own lifestyles. Look at students' transportation lifestyles. Work in small groups to answer the following questions:

1. Where do you need to go everyday? How do you reach your destination?

2. How do you get to school each day? Do you have other places where you need to go on a regular basis and need transportation? Identify the places in the table below.

Destination	Approximate Distance	Mode of Transportation	Options (Alternatives)
Example: **School**			

3. Discuss with your group the places to which you need to go. With your group select a transportation destination to explore.

4. Once the destination is identified, explore ways to measure the distance involved. Be creative in determining the distance. For example, measure how much distance you travel with each step. Walk the total distance and use mathematics to convert the amount. Identify some other ways to obtain the distance.

5. What other ways exist to reach your destination? Is the way you are using energy efficient? Interview a variety of adults and pose this problem. What options do they suggest?

CLOSURE:

Review your data and make some group recommendations about the most efficient ways to reach your destinations. Support your decision with data from the state agencies/library.

EVALUATION:

Prepare a two-paragraph statement with reasons for reducing our vehicular traffic. Interview a variety of people and gather information about their needs. Prepare a questionnaire so that the interview will be conducted in an objective way. Practice on your peers prior to using your questionnaire.

Summarize your data and review it with the other groups. What do you suggest? What can you do?

I Made a Map

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Maps from the American Automobile Association (AAA)
Local Maps
U.S. Geological Survey-Topographic Maps

MATHEMATICS STANDARDS:
Measurement
Geometry
Mathematics as Communication

OBJECTIVES: The students will learn:

1. To use measurement skills to develop a map everyone can follow.
2. To develop a rationale for the importance of scale.
3. To develop and apply skills of scale to create a map.

ACTIVITY:

BACKGROUND:

We all have used maps to find our way from one place to another. Going on vacations, looking for an unknown street, or having curiosity about a site are just a few reasons why we use maps. For this activity the class will be divided into mapping groups to make a real map of a local site.

Select a site that can be explored easily from your own school. Choose a site that might be environmentally improved after your mapping activity. Look at a variety of local maps.

MATERIALS:
Clipboard
Tape measures
Local site
Reference materials for botanicals
String

PROCEDURES:

1. Divide the class into 4 cooperative learning groups.
2. Decide on a site of predetermined size.
3. Look at a variety of maps to gain an understanding of the diversity and usefulness of maps. Most libraries have a collection of maps.
4. Develop a plan to proceed with this project to make a map of your chosen site.
5. Explore the concept of scale. Why is scale important? How can you assure accuracy?
6. Develop several preliminary maps. Trade with other groups and evaluate each other's maps.
7. Revise and improve your map after the peer evaluations.
8. Prepare your final map.

CLOSURE:

Review your map and make suggestions to improve this area environmentally.

Examples:
Is more shade appropriate?
Would a butterfly garden be appropriate?
Should some shrubs be planted for birds?
How could the area be upgraded?
Create a long-range plan for your area.
How could this area be visually more pleasing?

Present your final map and plan to your local city council. Explain reasons for the plan and costs of recommendations.

EVALUATION:

Take photos before, during, and after your map project or use a video camera. Make a presentation for your local park board, television station, or newspaper. Be concise but also precise. Use your data and skills to communicate this information.

THE WATER IN OUR WORLD

Acid Rain - pH Levels

LEVELS: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Stubbs, H. S. et al. (1985). *Elementary Acid Rain Kit, Grades 4-8.* St. Paul, MN: Acid Rain Foundation, Inc. (ERIC Document Reproduction Service No. ED 270 302).

MATHEMATICS STANDARDS:

Mathematical Connections
Number and Number Relationships
Patterns and Functions
Measurement

OBJECTIVES: The students will learn:

1. To classify substances as either acids or bases.
2. To compute the logarithmic change on the PM scale.
3. To represent this change on a string 101 cm long.

ACTIVITY:

BACKGROUND:

Before undertaking the exercises in this activity, it will be necessary to know the level of understanding of the students about acids and bases. Consultation with a science teacher would be helpful and a joint effort coordinating this activity is suggested. The Acid Rain Foundation has a booklet of science projects involving activities to develop understanding about acid rain. This activity will incorporate two of these activities to provide an integrated approach to understanding acid rain.

PROCEDURES:

These activities work well in the middle school setting where science and mathematics teachers often work together. Activity 1 would be supervised by the science teacher and would naturally lead into Activity 2, done by the mathematics teacher. Both activities would incorporate small-group work, with each group making its own findings.

Activity 1:

The first activity can be undertaken by the science class to understand how to classify substances as acids or bases.

"Acid Base Indicators," reproduced on Worksheet 1, is a discovery activity in which students will observe that substances can be divided into different classes according to how they react to the two types of litmus paper. Some substances will change only the red litmus paper, others only the blue litmus paper, and others will change neither. This observation will lead to the classification of substances as acidic, basic, or neutral. Activity 2 offers a good opportunity to see the effects of diluting on the ph value of a solution. This activity leads right into a discussion on the measurement of the acidity of a solution and the meaning of that value.

Activity 2:

"Concentration," reproduced on worksheet 2, can be used to make sense out of the ph scale and its link to logarithms. These two activities together illustrate the objectives of the NCTM Standards, connecting mathematics and science and giving students an opportunity to construct mathematics that describes the world around them.

CLOSURE:

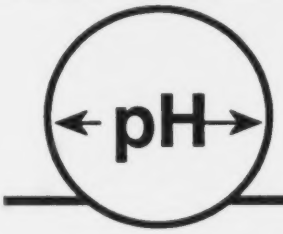
Small groups should report to the whole class, discussing their interpretations of the meaning of pH value and how it differs from other measurements they have encountered.

EVALUATION:

Construct examples that would require students to calculate changes in pH values based on quantities of water or acid that are added to a solution.

Have students find out some of the consequences of acid rain build up.

Worksheet 1: Acid Base Indicators



ACID BASE INDICATORS

This project is a beginning activity. "Normal" rain has the range of about pH 5-5.5. Acid Rain, less than pH 5.0 to 5.5, has been compared to many different substances, some of which are listed below.

Before You Begin: Describe the details of your experiment. What are you going to do? What equipment do you need? It may be useful to draw a diagram of your work. You do not have to use all substances listed. You may want to substitute others.

CHALLENGE 1

Find a Way to Group a Variety of Substances

Materials:

SAFETY GLASSES
Red litmus paper, 1 cm.
Blue litmus papers, 1 cm.
Small containers/baby food jars
Scissors
Forceps
Newspaper
Paper toweling
Mortar and pestle
Medicine droppers
Filter paper
Funnel
Ring stand

Substances:

Aspirin
Sugar
Distilled water
Cocoa
Indigestion tablets
Milk - fresh
Milk - sour
Vinegar
Rain water
Orange/lemon/juice
Salt
Toothpaste
Tea/coffee
Bottled water
Apple juice
Tap water
Bicarbonate of soda
Pond water

Directions:

1. Protect the surface on which you will be working.

2. Put on your safety glasses.

3. Add a level teaspoon of any one solid to 1/2 cup of water and stir until dissolved. For any of the tablets listed above, add one tablet to aone-half cup of water.

4. Use tweezerss to dip the litmus paper pieces into each solution. Do **not** re-use the litmus paper.

5. Record your observations. Make a table. Label each substance: A for acid, B for base, or N for neutral.

Acids are substances ehich turn blue litmus paper red.
Bases are substances ehich turn red litmus paper blue.
Substances which have no effects on either color of litmus paper are neutral.

6. Write a report on your idscoveries. It should include your objectives, hypothesis, procedures, observations and interpretations.

Figure 1: Taken from The Acid Rain Foundation, Inc. Copyright 1987.

Worksheet 2: pH Concentrations

The acidity of solutions, including rain or snow, is measured on a scale known as a pH scale. The scale is numbered from 0 to 14. A pH value of 7 is neutral, neither acidic nor basic. Values less than 7 are acidic; values above 7 are basic. A typical pH scale is drawn below.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

——Increasingly acidic——Neutral——Increasingly basic——

CHALLENGE 1

How much more concentrated is a pH of 3 than a pH of 4? A pH of 2 than a pH of 4?

MATERIALS:

Food coloring
Small containers/baby food jars
2 Medicine droppers
Water
String—101cm
Graph paper

Directions:

1. Add 10 drops of food coloring to an empty container. Consider this to be your strongest "acid." It has a "pH" of 1.

2. Remove 1 drop of food coloring. Place it in another container. Add 10 drops of water. It has a "pH" of _____.

3. Remove 1 drop of this solution. Place it in the next container. Add 10 drops of water. It has a "pH" of _____. Continue this procedure (label each step) three more times.

4. Each change of one pH unit—say from 6 to 5—represents an increase in acidity of:

10 100 1000 10,000 100,000 1,000,000

Worksheet 2 (cont.)

A change of pH from 4 to 1 represents an increase in acidity of:

10 100 1000 10,000 100,000 1,000,000

How is a pH scale different from a metric scale for measuring length?

CHALLENGE 2

You have a string 101 cm long. How can you represent the pH scale on it in a way that would help your class understand what is special about this scale? (You can use all the string except 1 cm.; this is for the rest of the scale, from 7-14). If you want, try this on a football field. The end zone can represent the rest of the scale.

Do We Have Wetlands?

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Use your local library and school resources.

MATHEMATICS STANDARDS:
Probability
Statistics
Communication

OBJECTIVES: The students will learn to:

1. Identify a wetland.
2. Synthesize wetland data into a local news article for publication.
3. Communicate about wetlands using mathematics.

ACTIVITY:

BACKGROUND:

The wetland controversy is in the papers and on the news on a regular basis. Farmland is being drained; developers are putting homes on land designated as wetland; and species are being eliminated as more habitats are lost. What is a wetland and does this controversy exist in your community?

MATERIALS:
Paper and Pencil
Library
State Department of Natural Resources brochures and other wetland data

PROCEDURES:

1. Have students work in pairs in a cooperative learning situation for this project. They will be interviewing people, seeking printed resources, and sharing information.

2. Students need to determine whether or not wetlands exist or existed in their community. Historical research and contemporary data are important. Interviews with senior citizens such as farmers, realtors, or building contractors are interesting sources of information. The state Department of Natural Resources is also a rich resource of materials and data on this topic.

3. Students need to focus on a wetland subject and not try to know everything that is available. A comprehensive list of potential topics will emerge from their research. This is a good time for each pair of researchers to identify a specific focus.

4. Creating mathematical charts, graphs, and articles will be a way to communicate their findings to the rest of the class. Are there some reports that overlap or are related? Do some reports contradict other reports? Prepare a final class summary of vital information. What conclusions can be recommended for action?

CLOSURE:

Prepare a videotape for your local television station on the local wetland challenge. Make it short and fast paced. Request that they view it and provide feedback to your class. (They may even decide to show it on television. Another option is to use the local community cable access network to show this production on television.)

EVALUATION:

Request that experts in the area of wetlands review your videotape and evaluate its comprehensiveness and accuracy.

Flowing Water

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES:

Mattingly, R. L. (1987, Dec.). The dynamics of flowing water. *Science Teacher, 54*(9), 23-27.

MATHEMATICAL STANDARDS:

Geometry
Problem Solving

OBJECTIVE: The student will learn:

1. To identify the relationship between the cross-sectional area of a channel and the volume of water passing through.
2. To compute the basic areas of different geometrical figures: rectangle, square, and trapezoid.
3. To use the guess and check method to solve problems.

ACTIVITY:

BACKGROUND:

Most students will have observed how the flow of water changes on a river. One minute it will be flowing very fast and then the next minute, it's meandering along. The amount of water flowing is essentially the same, but the channel in which it's flowing is different. The discharge of a river is the volume of water passing through a given cross-section of the channel during a given period. Its units are given in volume per unit time, e.g., 3 meters/sec. It would be interesting to explore how the change in the shape of the riverbed might affect the flow of the river.

MATERIALS:

Worksheets
Calculators
Graph paper with 1 cm squares

PROCEDURES:

After discussing the way in which the discharge of a river is calculated, present the worksheet provided. The problem should be solved in groups of 3 or 4. The graph paper would be given so that the trapezoid could be pictured using the grid to help the student visualize the cross-section. Calculators are helpful to quickly calculate the cross-sectional area.

Figure 1 below shows the area of trapezoidal cross-sections that students might be shown to give them an example of what they are looking for. The challenge is to create cross-sections with the given conditions.

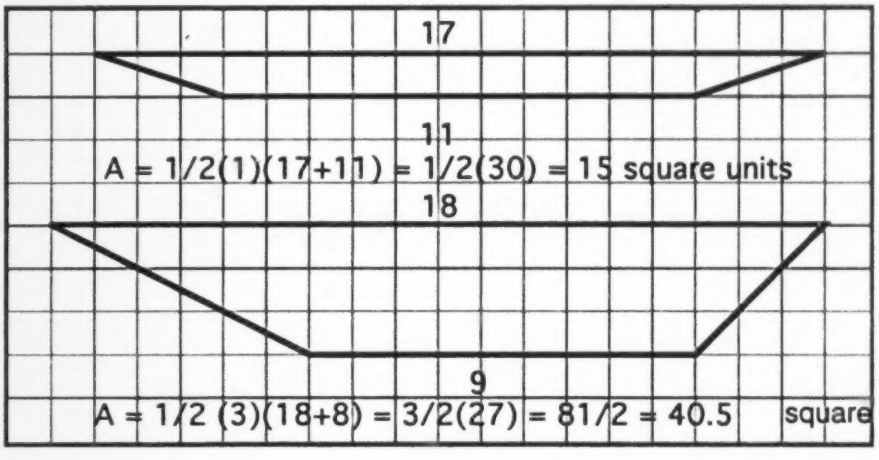


Figure 1.

CLOSURE:

Groups will present their conclusions and explain their strategies to solve the problem. Count up the number of different solutions to question 1 and discuss the number of potential solutions there are to this problem.

EVALUATION:

Ask the students to write in their journals the relationship between the shapes of the riverbeds and the speed of the water flowing in the river.

Worksheet: Flowing Water

A river passes through a narrow gorge that is 6 meters wide and 4 meters deep. The cross-section is nearly a rectangle in shape. The river then flattens out into a place where the distance across is now 20 meters and the shape of its cross-section is a trapezoid. Assuming that the river is flowing at the same rate:

1. Determine three trapazoidal cross-sections having different dimensions, but the same cross-sectional area. (Use your graph paper to draw the cross-section. Two examples of trapezoids are given below.)

2. What would be the dimensions of the trapezoid if you knew that the river was 1.5 meters deep in the middle?

3. What if the deepest part of the river were 3 meters from shore on one side and 5 meters from shore on the other side. How deep would the river be?

4. Suppose the water through the gorge flowed at 2 m/sec., but the flow at the flattened out portion was only 1 m/sec. How would this affect your answers for questions 1, 2, and 3?

It's a Whole New Wonderful World!

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Friedl, A. E. (1991). *Teaching science to children* (p. 215). NY: McGraw Hill.

MATHEMATICS STANDARDS:

Number and Number Relationships
Measurement
Problem Solving

OBJECTIVES: The students will learn:

1. Use creative writing as a means to illustrate a mathematics concept.

ACTIVITY:

BACKGROUND:

Humans became interested in the underwater world many years ago. It is believed that in 300 B.C. Alexander the Great viewed the wonders of the marine world from a large submerged diving bell. It was not until recent times, however, that serious attempts were made to actually live in underwater stations for days and weeks at a time. Life under water has a special fascination even today with scientists from all fields. Even in our complex world of science and advanced technology, we are still learning about the underwater world and its diverse life.

MATERIALS:

Underwater Pressures Table
Reference books about oceans

PROCEDURES:

Have the students explore some background materials from the library, e.g., books, pamphlets, videos. Each student is asked to create a fictional but scientifically accurate underwater story about a mathematician who finds a world of math under the sea. The students will use their classroom references to develop this adventure. The Underwater Pressures Table will provide some interesting mathematical data for the students as they proceed into the watery depths.

CLOSURE:

Share these stories with your peers. Have each person who reads your story create a mathematical question that might be explored by this mathematician during his or her adventure.

EVALUATION:

Critique another student's story. Is it scientifically and mathematically correct? Do some library research to validate the data in the adventure. Write a critique and share reasons for supporting or questioning this story.

UNDERWATER PRESSURES TABLE

DEPTH (m)	PRESSURE	COMMENTS
	1	
	2	No bends above 10 m; red light limit orange light limit
	3	Oxygen poisoning begins at 20 m.
30	4	
	5	Blue light limit
	6	Normal skindiving limit (50 m) "Nitrogen narcosis" begins (55 m)
60	7	Sea Lab II (62 m)
	8	
	9	Green light limit
90	10	Maximum momentary depth for air-breathing skindivers (100 m)
	11	
	12	Maximum depth for hard-hat divers (125 m)
120	13	Oxygen is only 2 percent of breathing mixture
	14	
	15	Depth limit for successful swim away from crippled submarine (145 m)
150	16	
	17	
	18	
180	19	Average depth of continental shelf
	20	
	21	
210	22	
	23	
	24	
240	25	
	26	
	27	
270	28	
	29	
	30	2/3 of 1 percent of breathing mixture is oxygen
	300	30 Keller and Small set Scuba diving record (Keller died)

Let's Live Near the Water

LEVEL: Grades 5-7

SUBJECT: Mathematics and Environmental Education

REFERENCES: United States Environmental Protection Agency. (1990). *Science demonstration projects in drinking water (grades k-12).* EPA 570/9-90-007. Washington, DC: EPA
Public or School Library for maps and local history texts to determine where settlers decided to live in the state

MATHEMATICS STANDARDS:
Mathematics as Reasoning
Number and Number Relationships

OBJECTIVES: The students will learn:

1. To utilize EPA and local data to look at water quality.
2. To seek data that will provide information about local cities and their use of the water resources.
3. To analyze data available to the public about local water resources.

ACTIVITY:

BACKGROUND:

People settled on rivers, lakes, and streams for many reasons. Why did people want to be near the water? Cities grew and water became even more important over time. People dumped their garbage, toxins, and human wastes into the water. They also drank, swam, and used the water for manufacturing purposes. With an increasing population, water resources have become critical in our society.

PROCEDURES:

1. Obtain data from your state EPA and local Department of Water Resources. Annual reports and educational materials will be very helpful. (See References.)
2. Have students work in groups of four. Each group looks at data tables and makes inferences from these tables. What has occurred? What is happening? What may occur in the future?

3. In your community what facilities are on the water? Take a one-mile walk along your water area and survey what is there. What kinds of activities are going on in this area? Does EPA keep any data on this?

4. What problems do you have locally with your water resources? What is being done? Do the data support this information?

CLOSURE:

Develop a television news spot using a video camera. Explain what you learned and challenge the community to work with the youth (future citizens) to develop a long-range plan. Begin monitoring this plan.

EVALUATION:

As you move into high school during the next few years, ask your mathematics and science teachers to help you continue to monitor this plan. Develop updates for television on what is occurring, using your original data and the most recent data.

The Undersea World of Disney

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Allen, R. F. (1983) *101 ways to teach about exponential growth and its consequences.* Sebring, FL: Tri-County Teacher Education Center. (ERIC Reproduction Service No. ED 225856)

MATHEMATICAL STANDARDS:

Numbers and Numerical Relationships
Problem Solving
Measurement

OBJECTIVES: The students will learn:

1. To identify the relationship between global warming and rising sea levels.
2. To read a contour map and determine the elevation of particular points.
3. To solve problems using information from the contour map.

ACTIVITY:

BACKGROUND:

The buildup in the Earth's atmosphere of the level of carbon dioxide (CO_2) has led to a concern that there will be a global warming—the "Greenhouse Effect." Allen (1983) gives a good description of what could occur and is included in the worksheet.

MATERIALS:

Contour map of Central Florida
Worksheets
Posterboard for maps

PROCEDURES:

Have the students read the background material on the worksheet and discuss it before breaking up into groups. The students will work on the problem posed on the worksheet.

CLOSURE:

Discuss the findings in the whole class. What precautions can we take now to avert this problem? What measure could we take if this phenomenon is irreversible?

EVALUATION:

Each student will be asked to make a new map of Florida if the seas were to rise by 10 feet.

Worksheet: The Undersea World of Disney

A recent review of the literature concludes that with a 2 percent annual rate of increase in worldwide consumption of fossil fuels (that is, essentially zero growth in per capita use of fossil fuels at the current world population growth rate) the average global temperature would increase by 0.5 to 2.5°C from the carbon dioxide buildup in the next 50 years. A degree of temperature matters little in a day's weather, but as a change in a global average, it means a lot.

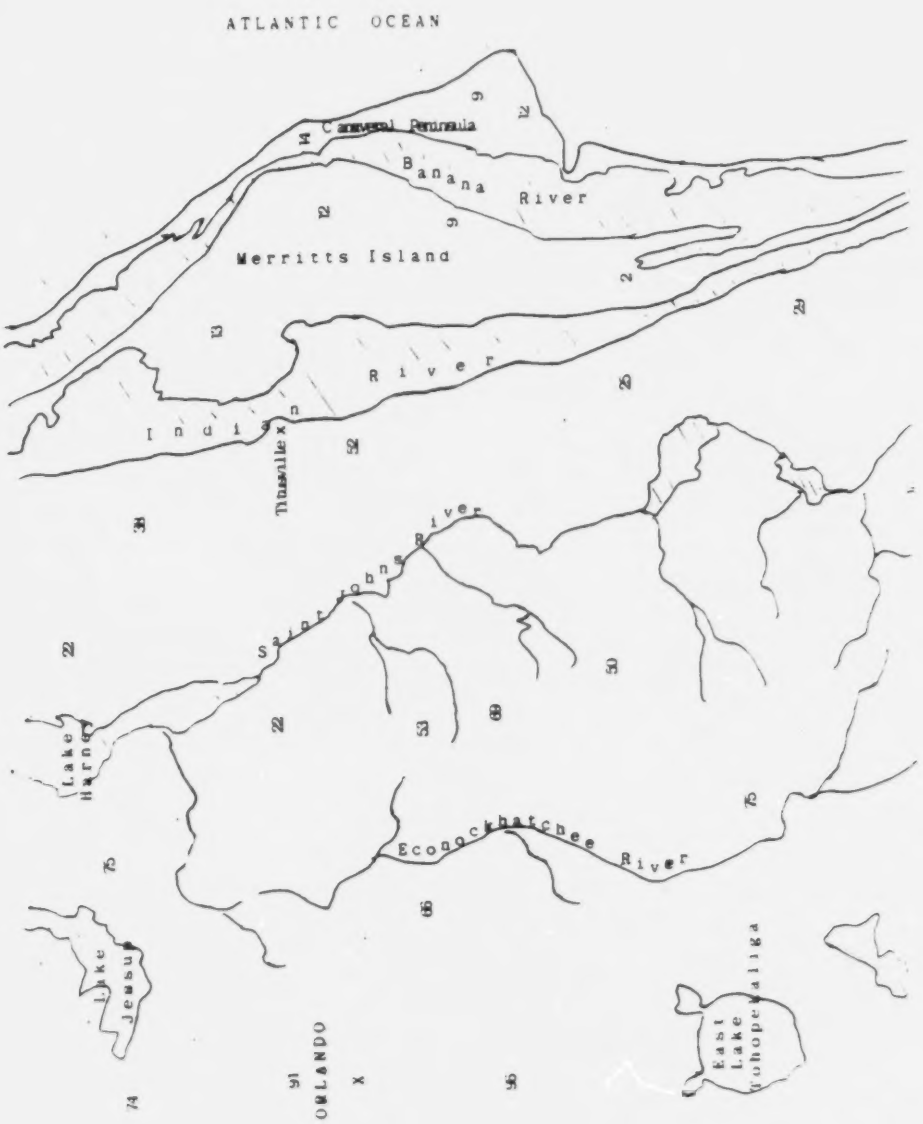
It is difficult to fully predict the effect of this global temperature rise. Some currently semi-arid regions would probably experience increased rainfall and some northern areas would probably enjoy longer growing seasons. But, some important food producing regions could be seriously damaged. If temperate-zone climates were to warm by some 2.2°C, then some atmospheric models predict that polar temperatures would rise by up to 8.8°C. That could well prove sufficient to change the temperature structure of the oceans, thus causing a major rise in sea level. The oceans contain some sixty times as much CO_2 as the atmosphere, and each degree of warming could release enough CO_2 to increase the atmospheric content by 3 percent, leading to still further warming.

The syndrome of human-generated CO_2, polar warming, deep ocean warming, and release of oceanic CO_2 could bring rapid, unplanned changes. There are enough fossil fuels available to produce a tenfold rise in CO_2 levels. Depending on the degree of polar warming and ice cap melting, the rise in world sea levels could exceed 100 ft. (Allen, 1983, p.109).

The "greenhouse effect" could produce increases in temperatures from 0.5°C to 2.5°C in temperate areas. For an increase of 1°C in the polar regions, melting of the polar cap would raise sea levels by 4 feet. What temperature increase in the temperate areas would cause Hollywood, Florida to be under the sea? What increase in temperature in temperate areas would cause Disney World in Orlando, Florida, to be reclaimed by the sea?

CONTOUR MAP OF FLORIDA

Numbers register the number of feet above sea level for each location.



Water: How Much Is Enough?

LEVEL: Grades 5-8

SUBJECT: Mathematics and Environment Education

REFERENCES: Hein, H. C. (1972). What is your share of the earth's water and air resources? *School Science and Mathematics, 72*(6), 469-70.

MATHEMATICS STANDARDS:

Measurement
Problem Solving
Number and Number Relationships

OBJECTIVES: The student will learn:

1. To measure the volume of water used in the home.
2. To calculate the volume of water necessary for an individual.
3. To solve practical problems involving water consumption.

ACTIVITY:

BACKGROUND:

The problem of water conservation is one that seems to affect a section of the country almost every year when one area or another becomes drought stricken. The year 1991 was difficult for California. However, that kind of severe drought may only be a short time away for almost everyone, and drinking water may soon be a precious commodity instead of being taken for granted.

MATERIALS:

Information from local Department of Water
Worksheets
Calculators

PROCEDURES:

Each local and state government has a department of water conservation that can supply specific information about water consumption and supply in the school locale. Discovering the water consumption for individuals and how that information might be used to solve problems involving water resources is an example of using mathematics to help students become more knowledgeable about their role in more global problems.

This activity will be conducted over a period of time, needing a short period of time initially, a reminder by the teacher before data collection, and one full class to synthesize the data and apply it to the problem situation. The stages of the activity are:

1. A discussion about how much water we use is initiated by the teacher. A list of all the ways in which we use water can be made by the class. The question of knowing how much we use can be raised, identifying how we quantify water consumption and how we can measure that quantity.
2. Worksheet 1 is distributed to the students, asking the students to estimate the amount of water consumed in their family in one week. Students will then need to register the current reading on the water meter in their homes, wait one week to get the second reading, and then calculate the average consumption per family member. (Students living in apartments may need to receive help from the landlord on their water consumption.)
3. Students are to bring this information to class with them the following week. Using this information, a weekly average consumption per person will be calculated. The students should initiate how that average should be calculated.
4. Worksheet 2 poses hypothetical questions about water use and consumption reduction. It will be distributed to the students and worked on in groups. Up-to-date information on water resources should be inserted into the blanks on the worksheet according to information supplied by the local Water Department.

CLOSURE:

Results from the group work should be reported and consequences of the situation should be discussed.

EVALUATION:

Different water conservation methods suggested in the class should be applied by students for a week. See if any change is registered. The percent of change should be calculated to see if those measures are significant enough to provide adequate water supplies during drought situations.

Worksheet 1

1. After hearing the discussion of how we measure water volume and the different ways in which we use water, estimate how much water your family uses per week.

2. Go home and find the water meter in your house or apartment and register a full week's consumption by reading the meter at a specific day and time, and rereading it one week later.

   1st reading:

   2nd reading:

3. Calculate the average consumption of water per week per person in your house.

4. How close was your estimate?

Worksheet 2

Your local Water Department estimates that the water reserve for your city is _____. If there are _____ people in town, use the average weekly consumption calculated by your class to answer the following problems.

1. If a drought were to begin today, how long would your water supply last?

2. What percent reduction would you need in weekly water consumption in order to have enough water for 8 extra weeks?

3. If your population increased by 25%, how long would the water supply last? by 50%? by 100%?

4. Is there any relationship between the percent of increase in the population and the percent of decrease in how long the water will last?

WEATHER AND THE AIR WE BREATHE

Is There a Chance It Will Rain?

LEVEL: Grades 6-8

SUBJECT: Mathematics and Environmental Education

REFERENCES: Local weather service.

MATHEMATICS STANDARD:
Probability
Reading Graphs
Reasoning

OBJECTIVES: Students will learn:

1. To understand what the phrase "the chance that it will rain" means.
2. To read the weather map to determine probabilities of rainfall.
3. To interpolate between contour lines to determine probabilities in different parts of the country.
4. To interpret the weather map and make appropriate decisions.

ACTIVITY:

BACKGROUND:

One area where students often refer to chance occurs when weather forecasters refer to the "chance that it will rain" as a certain percent. Students would benefit from understanding the meaning of this phrase and put it into perspective in dealing with the concept of probability. We often hear that there's a "70% chance of rain" when no rainfall occurs in our locale. The meaning of a weather forecaster reporting that there's a "70% chance of rain" is that, in the area reported for by the weather forecaster, there is a probability of 70/100 or 7/10 chance that .01 inches of precipitation will occur at any given point in that area. It is for this reason that weather forecasters will report a slight chance of rain, isolated showers, or widely scattered thunderstorms, more often than a certain percent chance of rain. The maps used in this activity are actual maps supplied to weather forecasters by the National Weather Bureau. If teachers want more up-to-date information, they may contact local weather services.

MATERIALS:

Weather maps
Worksheets
Blackboard or overhead

PROCEDURES:

Discuss the concept of "chance that it will rain" with the students as a class. Listing students' interpretations would be appropriate before giving the definitions from above. Have the students guess why there may be a discrepancy between the percentages of chances predicted and actual precipitation registered.

Then:

1. Present the actual definition of the meaning of saying there's a "70% chance of rainfall" in a given day.
2. Present a copy of one of the maps registering the chances of precipitation over 4 twelve-hour periods. Let the students try to figure out what the numbers might mean. The teacher should understand that the contour lines indicate the percentages of possible precipitation. For example, in map 1, the southern tip of Florida can expect 65% or more chance of rain, while central Florida can have between 55% and 65% chance of rain.

When students understand how to read the map, have them pair off and complete the worksheet. Teachers may want to extend the concept by using the map and discuss successive days, finding the probability of it raining both days, neither day, etc.

CLOSURE:

Let the full class reconvene, and have different groups present and explain their answers to the class for the questions. Different answers are likely and will reinforce the idea that some mathematics problems do not necessarily have unique answers.

EVALUATION:

Have students explain in their own words how probability relates to what it means when the weather forecaster says that there's a 50% chance of rain.

Worksheet

1. According to the weather maps, from 12:00 noon on 8/22/91 to 12:00 noon on 8/24/91, what were the highest chances of it raining at your house in any 12-hour period?

2. Name two places in the U.S., one in the east and another in the west, where the chances of it raining were 15% from 12:00 noon to midnight on 8/23/91.

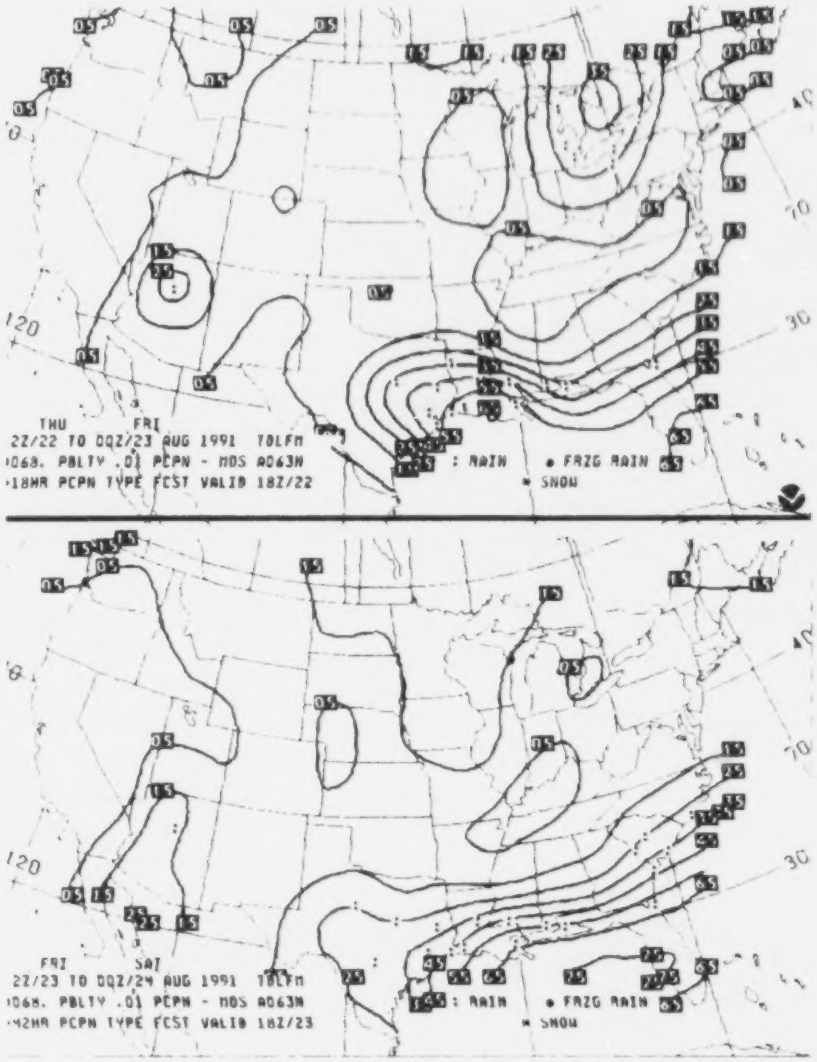
3. Where was it most likely to rain in the U.S. on 8/24/91?

4. What were the chances of rain in Oklahoma on the morning of 8/23/91?

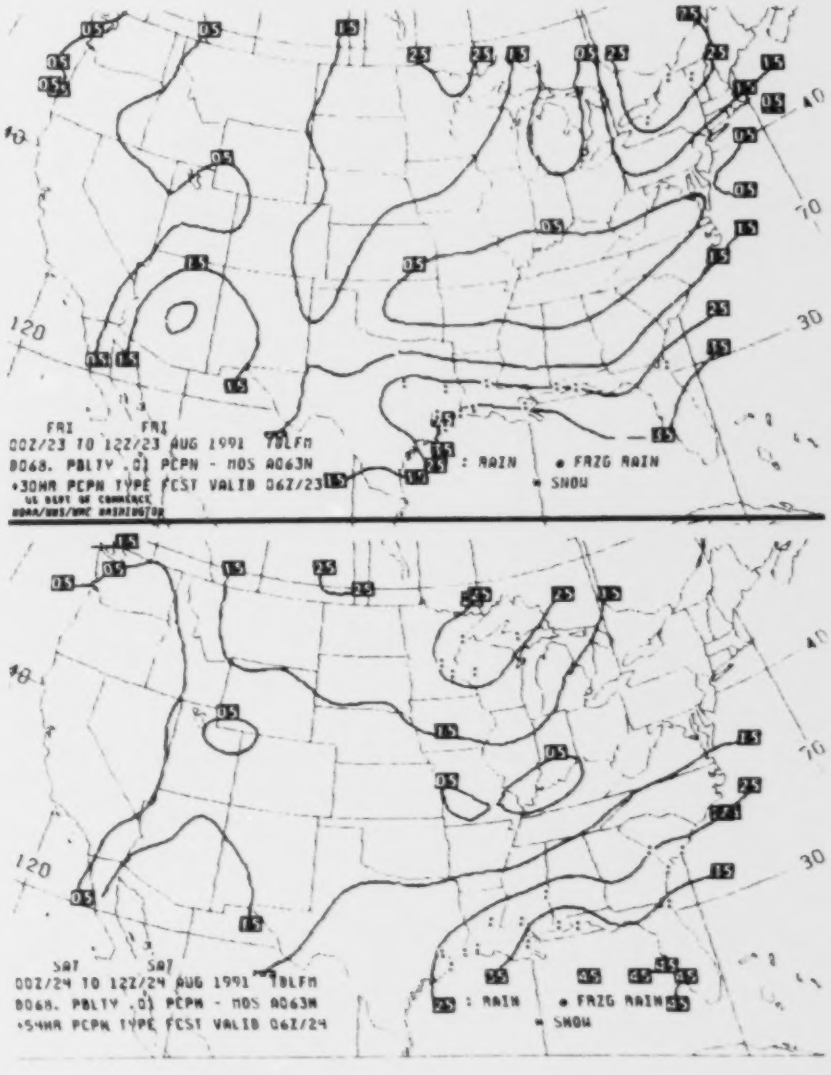
5. If you wanted to imagine clouds in the map, where would you put the highest and lowest concentration of clouds on 8/23/91?

6. What are the "chances" that it doesn't rain in New York City for the morning of 8/24/91?

Weather Maps 1 and 2


THU FRI
22/22 TO 00Z/23 AUG 1991 TDLFM
068. PBLTY .01 PCPN - MOS 0063M
18HR PCPN TYPE FCST VALID 18Z/22
: RAIN
• FRZG RAIN
* SNOW
FRI SAT
22/23 TO 00Z/24 AUG 1991 TDLFM
068. PBLTY .01 PCPN - MOS 0063M
42HR PCPN TYPE FCST VALID 18Z/23
: RAIN
• FRZG RAIN
* SNOW

Weather Maps 3 and 4


FRI FRI
00Z/23 TO 12Z/23 AUG 1991 TBLFM
0068. PBLTY .01 PCPN - MOS 0063M
+30HR PCPN TYPE FCST VALID 06Z/23
: RAIN
• FRZG RAIN
▪ SNOW
SAT SAT
00Z/24 TO 12Z/24 AUG 1991 TBLFM
0068. PBLTY .01 PCPN - MOS 0063M
+54HR PCPN TYPE FCST VALID 06Z/24
: RAIN
• FRZG RAIN
▪ SNOW

What Will Our Weather Be?

LEVEL: Grades 6-8

SUBJECT: Mathematics and Meteorology

REFERENCES: Bomeli, C. L. (1991). Mathematics and meteorology: Perfect partners. *School Science and Mathematics, 9*(1), 31-33.
Roberts, F. (1985). Using weather projects to make science relevant. *Science Scope, 8*(4), 33.

MATHEMATICS STANDARD:
Patterns and Functions

OBJECTIVES: Students will learn:

1. To organize and represent data in a graph.
2. To interpret data to predict outcomes.
3. To describe in writing their projects and present them to the class.

ACTIVITY:

BACKGROUND:

Providing middle school students with experiences that touch their personal lives is an important way to stimulate their curiosity about a subject. Graphing meteorological data about a student's home town or the city closest to home can provide that source of stimulation. We all complain about the weather and its seemingly erratic behavior. By documenting a month's worth of data regarding temperature and rainfall or snowfall, we can teach the concepts of graphing. At the same time we can reinforce the concept of averages and the use of prior experiences to predict future outcomes. The following questions can be asked to show the way in which these skills can be applied to our daily lives: (1) How does the ability to predict weather affect your lives? and (2) What occupation might depend on knowledge of temperature and rainfall?

MATERIALS:

Access to the local newspaper at the library to record data from the previous year
Graph paper
Calculators

PROCEDURES:

1. Place students in groups of 4.
2. Have the groups use library sources to determine the exact temperatures and rainfall (precipitation) for the agreed-upon period from the previous year for different cities in their area. (The teacher will need to decide when during the school year the introduction of the topic is pertinent.)
3. Have the students organize and present the data in a graph of their choice. Their choice should be based upon criteria that best conveys the meaning of the data. An example is provided in Figure 1.
4. Based on this data, have the group predict the average temperature and rainfalls for their chosen cities.

CLOSURE:

1. Group reports will be done, displaying their graphs and their predictions.
2. Follow-up data will be collected so that at the end of the period of time, students will determine if the predictions made were accurate or not.

EVALUATION:

1. Groups will be assessed on the written reports, and their justification of their choices of graphs.
2. Groups are asked how knowledge of weather patterns can relate to specific environmental issues (e.g., energy consumption for winter heating, planting patterns for farmers, etc.).

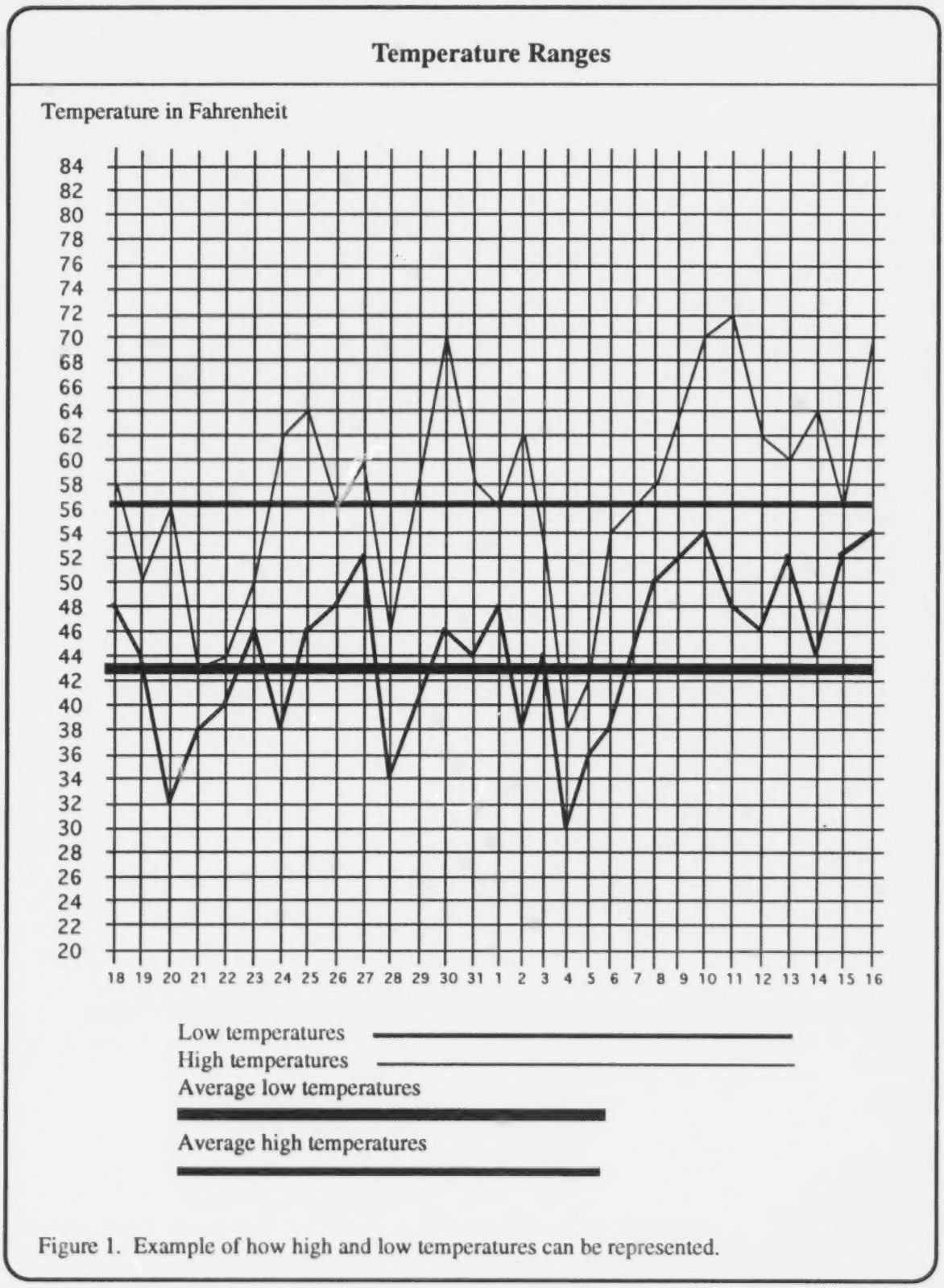


Figure 1. Example of how high and low temperatures can be represented.

Summary

The NCTM *Standards* identifies eight topics that should be utilized as specific curriculum topics. This publication has identified some enriching environmental/math activities to expand and enhance the student's experiences. Every activity has an open-ended framework that allows learners to enter the learning continuum at their own level of expertise and proceed at their personal learning pace. Students will be encouraged to focus on problem solving and critical thinking strategies used in the adopted course of study. This transfer of skills to a combined mathematics/environmental setting allows students to explore the world around them. Students will construct their own environmental frameworks using their own world and their mathematical knowledge. The lesson's sophistication depends upon the individual classroom communities of learners. These activities are meant to enhance the ongoing course of study and encourage the integration of environmental science and mathematics in developing new constructs. Manipulatives, technology, and opportunities to generate data are incorporated into each of the enriching activities.

This publication was developed to demonstrate the numerous possibilities that exist in the environmental /mathematics arena. Mathematics in the environmental context is an area in which students are readily motivated. All of the activities create a participatory learning community in the classroom. The activities are MODELS drawn from an unbelievable number of potential activities available to educators. These activities were selected to show a variety of open-ended, multi-faceted activities. Where learners go with each of these experiences will be unknown until given an opportunity to explore for themselves. Students will also expand these activities and go in many different directions. The NCTM *Standards* can be supplemented by having publications of this type to model potential activities.

Teachers may be surprised to find no extensive reference and additional resource bibliography. Practical experience indicates that teachers do not have time to use that section. Most teachers check with the school or community librarian and provide the topic. The librarian can identify what is locally available. Many schools now have computers with modems which can connect the students to data bases to locate additional materials on their own. Some students have even talked, via the computer, to resources in other countries.

This publication is designed with activities that allow learners to expand the context themselves. The reader needs to be aware that the more context students are provided, the less adaptable the learners will be as they explore the activities. The possibility for multiple strategies is also enhanced with the format of these activities.

It is crucial that local issues which relate to various activities in this publication be integrated into the activity. Local speakers, reporters, news articles, video tapes, commission reports, and state agency data as well as other local resources can be identified. Hopefully, the students will become the investigators to pursue the local issues and develop relevant constructs.

This is an exciting way to learn mathematics as well as an exciting way to teach mathematics. It needs to be mentioned that answers are not a major part of this collection. Students will have an opportunity to generate new data and develop stronger constructs as a result of these reality based experiences.

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Office of Educational Research and Improvement
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NOTES